

SUMMARY OF PUBLISHED AQUATIC TOXICITY INFORMATION AND WATER- QUALITY CRITERIA FOR SELECTED VOLATILE ORGANIC COMPOUNDS

U.S. GEOLOGICAL SURVEY

Open-File Report 97-563



NATIONAL WATER-QUALITY ASSESSMENT PROGRAM



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By Barbara L. Rowe, Sondra J. Landrigan, and Thomas J. Lopes

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FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policy-makers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for a specific contamination problem; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.

- Describe how water quality is changing over time.

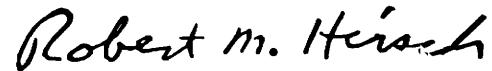
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 59 of the Nation's most important river basins and aquifer systems, which are referred to as Study Units. These Study Units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 59 Study Units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the Study Units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.



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Chief Hydrologist

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Summary of Published Aquatic Toxicity Information and Water-Quality Criteria for Selected Volatile Organic Compounds

By Barbara L. Rowe, Sondra J. Landrigan, and Thomas J. Lopes

ABSTRACT

Volatile organic compounds (VOCs) are being measured in stream samples as part of the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program. Published freshwater aquatic toxicity information and water-quality criteria for VOCs were compiled to compare with the measured concentrations. Aquatic toxicity information for VOCs was retrieved from the U.S. Environmental Protection Agency's (USEPA's) toxicity data base, AQUatic toxicity Information REtrieval (AQUIRE). Toxicity information that had complete or moderately complete documentation was available for 60 of the 87 VOCs that are being measured in water samples. Most toxicity information was from studies of 96 hours or less, and species mortality was typically the endpoint of the toxicity test. A number of published studies using the same species, duration, and endpoint were available for some VOCs. In these instances, only the two studies that reported the lowest concentrations that had an effect were included in the summary. VOCs that had the lowest concentrations that affected a species ranged between 6.5 µg/L (micrograms per liter) for 1,1,2,3,4,4-hexachloro-1,3-butadiene and 5,091,000 µg/L for 2-butanone.

The USEPA and Canadian Council of Resource and Environment Ministers have established water-quality criteria and guidelines for 39 of the 87 VOCs measured in water samples by the NAWQA Program. Criteria and guidelines range

from 0.1 µg/L for 1,1,2,3,4,4-hexachloro-1,3-butadiene to 860,000 µg/L for 3-chloro-1-propene and chloroethane. These water-quality criteria, guidelines, and toxicity information will be used by NAWQA to assess the status of the Nation's water quality and are available for use by individuals, agencies, and organizations to evaluate the potential effect of VOCs on aquatic life in streams and rivers.

INTRODUCTION

The National Water-Quality Assessment (NAWQA) Program of the U.S. Geological Survey (USGS) is a systematic assessment of the quality of the Nation's water resources. The primary goals of NAWQA are to describe the status and trends in the quality of a large, representative part of the Nation's surface-water and ground-water resources and to identify the primary natural and human factors affecting the quality of these resources. The design of NAWQA, discussed in detail by Gilliom and others (1995), is organized around 59 Study Units (fig. 1) that include sections of most of the Nation's major river basins and aquifers. The starting dates of Study-Unit Investigations are staggered between fiscal years 1991 and 1997, and at any time water-quality data are being collected in about 16 to 20 Study Units.

Another component of the NAWQA Program is National Synthesis Investigations (NSIs), which are focused on specific groups of contaminants. In part, these investigations compile, analyze, and report water-quality data (collected by Study Units) on a

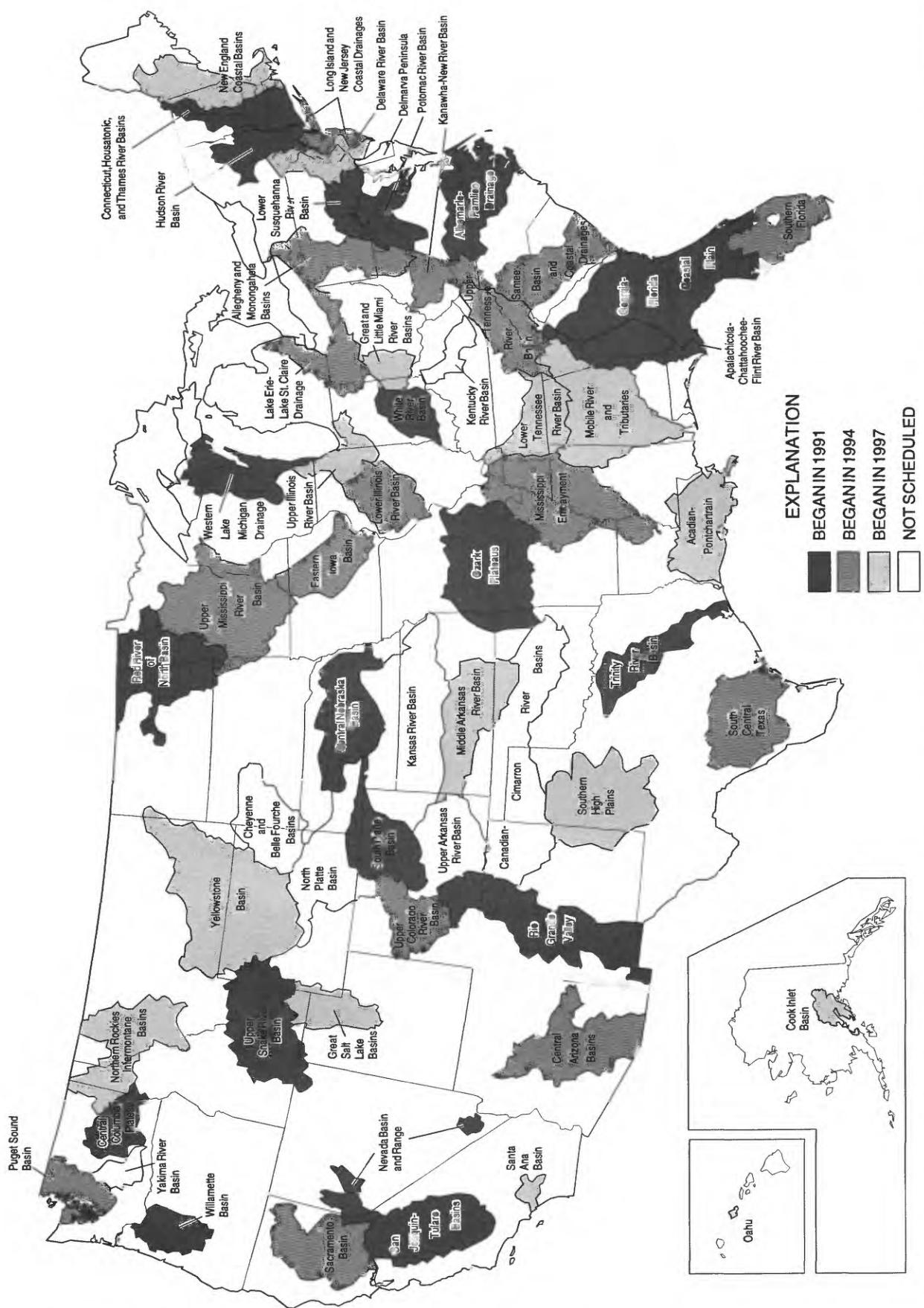


Figure 1. Location of National Water-Quality Assessment Program Study Units and their proposed implementation dates (modified from Gillion and others, 1995, fig. 1).

national scale. The NSI for pesticides and the NSI for nutrients began in 1991, and the NSI for volatile organic compounds (VOCs) began in 1993. Two additional NSIs are in the planning process, including aquatic ecology and trace elements. VOCs are being sampled mostly in areas with predominantly residential and commercial land use in metropolitan areas with a population of 250,000 or more (Squillace and Price, 1996; Lopes and Price, 1997).

Water samples collected for the NAWQA Program are analyzed for VOCs at the USGS National Water-Quality Laboratory (NWQL) in Arvada, Colorado, using a new analytical method. This method quantifies low levels of VOCs in ambient surface water and ground water. The method is based upon U.S. Environmental Protection Agency (USEPA) Method 524.2, Revision 4.0 (Eichelberger and Budde, 1989) and USGS Open-File Report 94-708 (Rose and Schroeder, 1994), with improvement of instrument-operating conditions, increased number of compounds analyzed, modifications to identification criteria, and inclusion of data-reporting strategies for low-level detections. Due to the increasing need for lower concentration data, in part, to identify potentially harmful environmental contaminants in water, the NWQL quantifies 87 analytes at or below the methods detection level if (1) all criteria for analyte identification are met, and (2) the laboratory analysis is not limited by laboratory contamination of VOC samples.

Analytes measured using the new USGS VOC method are divided into two groups: NAWQA target analytes (55 compounds), and other analytes (32 compounds). NAWQA target analytes were selected for emphasis in the NAWQA Program because of their known human-health and (or) aquatic-life concern or because of their high frequency of occurrence in surface water and ground water (John Zogorski, USGS, written commun., 1994). The "other analytes" measured using the new VOC method (table 1) were included because they are on the USEPA's revised method for drinking water.

The purpose of this report is to summarize published aquatic toxicity information and water-quality criteria and guidelines for VOCs that are measured by the NAWQA Program. This published information is needed for comparisons with concentrations measured in streams and rivers by the NAWQA Program and for assessing the status of water quality.

All aquatic toxicity information presented in this report was retrieved from AQUatic toxicity Informa-

tion REtrieval (AQUIRE) (U.S. Environmental Protection Agency, 1996a). Toxicity data have been reviewed to update AQUIRE on a quarterly basis during the past 14 years. Data exchanges with the Organization for Economic Cooperation and Development, Paris, France, and with the Bor'k Institute, Nekouz, Yaroslavsky Region, Russian Republic, have made AQUIRE a centralized, international source for toxic effects information.

Water-quality criteria and guidelines were compiled from the Integrated Risk Information System (IRIS) (U.S. Environmental Protection Agency, 1996b) and from the Canadian Council of Resource and Environment Ministers (1991).

DESCRIPTION OF AQUATIC TOXICITY INFORMATION

Toxicity tests typically are conducted by exposing organisms to a range of contaminant concentrations under controlled conditions and measuring the response of the organisms (Rand and Petrocelli, 1985). Acute toxicity tests are used to determine if solutions are toxic to species during short-duration exposures (typically 96 hours or less), and species mortality is the most common endpoint. Chronic toxicity tests use a longer duration of exposure (typically 7 days or more). Responses other than species mortality typically are measured during chronic tests and may include growth, reproduction, and behavior. No exact duration or response, however, distinguishes acute and chronic toxicity tests. Laboratory controls are an important part of toxicity tests and are used to ensure that species mortality or other adverse reactions of a test organism are due to the contaminant and not the testing procedure or natural causes. Laboratory controls are performed the same as toxicity tests; however, organisms are not exposed to the contaminant.

The majority of published information for VOCs are median lethal concentration (LC_{50}) values, which are the estimated concentrations at which 50 percent of the organisms died during the toxicity test. The LC_{50} is estimated by interpolating species mortality rates from the range in concentrations used in the toxicity test. If the largest concentration did not result in 50-percent mortality, then the LC_{50} is reported as greater than the largest concentration. The effective mean concentration (EC_{50}) is the estimated concentration that affects 50 percent of the organisms; however, the endpoint of the test is an effect other than mortality.

Table 1. Volatile organic compounds measured by the U.S. Geological Survey National Water-Quality Assessment Program

[Compounds are identified by the following: PCODE, U.S. Geological Survey parameter code; CAS no., Chemical Abstract Services number; IUPAC, International Union of Pure and Applied Chemistry]

PCODE	CAS no.	IUPAC compound name (chemical formula) (common name(s))	PCODE	CAS no.	IUPAC compound name (chemical formula) (common name(s))
Target analytes					
34030	71-43-2	Benzene (C ₆ H ₆)	34541	78-87-5	1,2-Dichloropropane (C ₃ H ₆ Cl ₂) (propylene dichloride)
32101	75-27-4	Bromodichloromethane (CHBrCl ₂) (dichlorobromomethane)	34704	10061-01-5	<i>cis</i> -1,3-Dichloropropene (C ₃ H ₄ Cl ₂) ((Z)-1,3-dichloropropene)
50002	593-60-2	Bromoethene (C ₂ H ₃ Br) (vinyl bromide)	34699	10061-02-6	<i>trans</i> -1,3-Dichloropropene (C ₃ H ₄ Cl ₂) ((E)-1,3-dichloropropene)
34413	74-83-9	Bromomethane (CH ₃ Br) (methyl bromide)	77135	95-47-6	1,2-Dimethylbenzene (C ₈ H ₁₀) (<i>o</i> -xylene)
77342	104-51-8	<i>n</i> -Butylbenzene (C ₁₀ H ₁₄) (1-phenylbutane)	85795	108-38-3	1,3-Dimethylbenzene (C ₈ H ₁₀) (<i>m</i> -xylene) and
34301	108-90-7	Chlorobenzene (C ₆ H ₅ Cl) (monochlorobenzene)		106-42-3	1,4-Dimethylbenzene (C ₈ H ₁₀) (<i>p</i> -xylene)
34311	75-00-3	Chloroethane (C ₂ H ₅ Cl) (ethyl chloride)	77128	100-42-5	Ethenylbenzene (C ₈ H ₈) (styrene)
39175	75-01-4	Chloroethene (C ₂ H ₃ Cl) (vinyl chloride)	50004	637-92-3	2-Ethoxy-2-methylpropane (C ₆ H ₁₄ O) (ethyl <i>tert</i> -butyl ether, ETBE)
34418	74-87-3	Chloromethane (CH ₃ Cl) (methyl chloride)	34371	100-41-4	Ethylbenzene (C ₈ H ₁₀) (phenylethane)
82625	96-12-8	1,2-Dibromo-3-chloropropane (C ₃ H ₅ Br ₂ Cl) (dibromochloropropane, DBCP)	39702	87-68-3	1,1,2,3,4,4-Hexachloro-1,3-butadiene (C ₄ Cl ₆) (hexachlorobutadiene)
32105	124-48-1	Dibromochloromethane (CHBr ₂ Cl) (chlorodibromomethane)	34396	67-72-1	1,1,1,2,2,2-Hexachloroethane (C ₂ Cl ₆) (carbon hexachloride)
77651	106-93-4	1,2-Dibromoethane (C ₂ H ₄ Br ₂) (ethylene dibromide, EDB)	50005	994-05-8	2-Methoxy-2-methylbutane (C ₆ H ₁₄ O) (<i>tert</i> -amyl methyl ether, TAME)
34536	95-50-1	1,2-Dichlorobenzene (C ₆ H ₄ Cl ₂) (<i>o</i> -dichlorobenzene)	78032	1634-04-4	2-Methoxy-2-methylpropane (C ₅ H ₁₂ O) (methyl <i>tert</i> -butyl ether, MTBE)
34566	541-73-1	1,3-Dichlorobenzene (C ₆ H ₄ Cl ₂) (<i>m</i> -dichlorobenzene)	34010	108-88-3	Methylbenzene (C ₇ H ₈) (toluene)
34571	106-46-7	1,4-Dichlorobenzene (C ₆ H ₄ Cl ₂) (<i>p</i> -dichlorobenzene)	77223	98-82-8	(1-Methylethyl)benzene (C ₉ H ₁₂) (isopropylbenzene)
34668	75-71-8	Dichlorodifluoromethane (CCl ₂ F ₂) (CFC 12)	34696	91-20-3	Naphthalene (C ₁₀ H ₈)
34496	75-34-3	1,1-Dichloroethane (C ₂ H ₄ Cl ₂) (ethylidene chloride)	81577	108-20-3	2,2'-oxybis[propane] (C ₆ H ₁₄ O) (diisopropyl ether, DIPE)
32103	107-06-2	1,2-Dichloroethane (C ₂ H ₄ Cl ₂) (ethylene dichloride)	34210	107-02-8	2-Propenal (C ₃ H ₄ O) (acrolein)
34501	75-35-4	1,1-Dichloroethene (C ₂ H ₂ Cl ₂) (vinylidene chloride)	34215	107-13-1	2-Propenenitrile (C ₃ H ₃ N) (acrylonitrile)
77093	156-59-2	<i>cis</i> -1,2-Dichloroethene (C ₂ H ₂ Cl ₂) ((Z)-1,2-dichloroethene)	77224	103-65-1	<i>n</i> -Propylbenzene (C ₉ H ₁₂) (1-phenylpropane)
34546	156-60-5	<i>trans</i> -1,2-Dichloroethene (C ₂ H ₂ Cl ₂) ((E)-1,2-dichloroethene)	34475	127-18-4	Tetrachloroethene (C ₂ Cl ₄) (perchloroethene, PCE)
34423	75-09-2	Dichloromethane (CH ₂ Cl ₂) (methylene chloride)	32102	56-23-5	Tetrachloromethane (CCl ₄) (carbon tetrachloride)

Table 1. Volatile organic compounds measured by the U.S. Geological Survey National Water-Quality Assessment Program—Continued

PCODE	CAS no.	IUPAC compound name (chemical formula) (common name(s))	PCODE	CAS no.	IUPAC compound name (chemical formula) (common name(s))
Target analytes—Continued					
32104	75-25-2	Tribromomethane (CHBr_3) (bromoform)	39180	79-01-6	Trichloroethene (C_2HCl_3) (trichloroethylene, TCE)
77652	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane ($\text{C}_2\text{Cl}_3\text{F}_3$) (CFC 113)	34488	75-69-4	Trichlorofluoromethane (CCl_3F) (CFC 11)
77613	87-61-6	1,2,3-Trichlorobenzene ($\text{C}_6\text{H}_3\text{Cl}_3$)	32106	67-66-3	Trichloromethane (CHCl_3) (chloroform)
34551	120-82-1	1,2,4-Trichlorobenzene ($\text{C}_6\text{H}_3\text{Cl}_3$)	77443	96-18-4	1,2,3-Trichloropropane ($\text{C}_3\text{H}_5\text{Cl}_3$) (allyl trichloride)
34506	71-55-6	1,1,1-Trichloroethane ($\text{C}_2\text{H}_3\text{Cl}_3$) (methylchloroform)	77222	95-63-6	1,2,4-Trimethylbenzene (C_9H_{12}) (pseudocumene)
34511	79-00-5	1,1,2-Trichloroethane ($\text{C}_2\text{H}_3\text{Cl}_3$) (vinyl trichloride)	Other analytes		
81555	108-86-1	Bromobenzene ($\text{C}_6\text{H}_5\text{Br}$) (phenyl bromide)	77103	591-78-6	2-Hexanone ($\text{C}_6\text{H}_{12}\text{O}$) (butyl methyl ketone, MBK)
77297	74-97-5	Bromochloromethane (CH_2BrCl) (methylene chlorobromide)	77424	74-88-4	Iodomethane (CH_3I) (methyl iodide)
81595	78-93-3	2-Butanone ($\text{C}_4\text{H}_8\text{O}$) (methyl ethyl ketone, MEK)	77356	99-87-6	1-Isopropyl-4-methylbenzene ($\text{C}_{10}\text{H}_{14}$) (<i>p</i> -isopropyltoluene)
77041	75-15-0	Carbon disulfide (CS_2)	81597	80-62-6	Methyl 2-methyl-2-propenoate ($\text{C}_5\text{H}_8\text{O}_2$) (methyl methacrylate)
77275	95-49-8	1-Chloro-2-methylbenzene ($\text{C}_7\text{H}_7\text{Cl}$) (<i>o</i> -chlorotoluene)	78133	108-10-1	4-Methyl-2-pentanone ($\text{C}_6\text{H}_{12}\text{O}$) (isobutyl methyl ketone, MIK)
77277	106-43-4	1-Chloro-4-methylbenzene ($\text{C}_7\text{H}_7\text{Cl}$) (<i>p</i> -chlorotoluene)	81593	126-98-7	2-Methyl-2-propenenitrile ($\text{C}_4\text{H}_5\text{N}$) (methyl acrylonitrile)
78109	107-05-1	3-Chloro-1-propene ($\text{C}_3\text{H}_5\text{Cl}$) (allyl chloride)	49991	96-33-3	Methyl-2-propenoate ($\text{C}_4\text{H}_6\text{O}_2$) (methyl acrylate)
30217	74-95-3	Dibromomethane (CH_2Br_2) (methylene bromide)	77350	135-98-8	(1-Methylpropyl)benzene ($\text{C}_{10}\text{H}_{14}$) (<i>sec</i> -butylbenzene)
73547	110-57-6	<i>trans</i> -1,4-Dichloro-2-butene ($\text{C}_4\text{H}_6\text{Cl}_2$) (<i>E</i> -1,4-dichloro-2-butene)	81576	60-29-7	1,1'-Oxybisethane ($\text{C}_4\text{H}_{10}\text{O}$) (diethyl ether)
77173	142-28-9	1,3-Dichloropropane ($\text{C}_3\text{H}_6\text{Cl}_2$) (trimethylene dichloride)	81552	67-64-1	2-Propanone ($\text{C}_3\text{H}_6\text{O}$) (acetone)
77170	594-20-7	2,2-Dichloropropane ($\text{C}_3\text{H}_6\text{Cl}_2$)	77562	630-20-6	1,1,1,2-Tetrachloroethane ($\text{C}_2\text{H}_2\text{Cl}_4$)
77168	563-58-6	1,1-Dichloropropene ($\text{C}_3\text{H}_4\text{Cl}_2$)	34516	79-34-5	1,1,2,2-Tetrachloroethane ($\text{C}_2\text{H}_2\text{Cl}_4$)
77353	98-06-6	(1,1-Dimethylethyl)benzene (<i>tert</i> -butylbenzene)	49999	488-23-3	1,2,3,4-Tetramethylbenzene ($\text{C}_{10}\text{H}_{14}$) (prehitene)
81607	109-99-9	1,4-Epoxybutane ($\text{C}_4\text{H}_8\text{O}$) (tetrahydrofuran)	50000	527-53-7	1,2,3,5-Tetramethylbenzene ($\text{C}_{10}\text{H}_{14}$) (isodurene)
77220	611-14-3	1-Ethyl-2-methylbenzene (C_9H_{12}) (2-ethyltoluene)	77221	526-73-8	1,2,3-Trimethylbenzene (C_9H_{12}) (hemimellitene)
73570	97-63-2	Ethyl 2-methyl-2-propenoate ($\text{C}_6\text{H}_{10}\text{O}_2$) (ethyl methacrylate)	77226	108-67-8	1,3,5-Trimethylbenzene (C_9H_{12}) (mesitylene)

Other toxicity information for VOCs include: (1) no-observed effective concentration (NOEC), the highest concentration at which observed effects are not found or are not statistically significant; (2) lowest-observed effective concentration (LOEC), the lowest concentration producing a statistically significant effect; and (3) maximum-acceptable toxicant concentration, the chronic value representing the hypothetical threshold concentration that is the geometric mean between the NOEC and LOEC concentrations.

For most VOCs, toxicity information is available for only one or two test species. AQUIRE had no information for 13 NAWQA target analytes and 13 other analytes (table 2).

Retrieval from AQUIRE

Selected toxicity information was retrieved from AQUIRE by specifying the VOC and ancillary information including: chemical name recognized by the International Union of Pure and Applied Chemistry and common name, Chemical Abstracts registry number, taxonomic classification (latin and common name) of test species, number of studies (n) performed on each VOC, duration of exposure, concentration of the endpoint (for example, LC₅₀), measured effect code that qualifies the documentation of test procedures, and source number indicating the study reference. Not all entries in AQUIRE have the ancillary information that were specified in the retrievals.

Criteria for Compilation of Information

To be included in this report, information from AQUIRE was reviewed to determine if the following two criteria were met: (1) studies must have been conducted in freshwater, and (2) studies must have complete or moderately complete documentation of test procedures. A number of studies using the same species, duration, and endpoint were available for some VOCs. In these instances, only the two studies that reported the lowest concentrations that had an effect were included in the compilation at the end of this report in the Aquatic Toxicity Information for Selected Volatile Organic Compounds section (table 5) and in the References Containing Aquatic Toxicity Information section (table 6).

Table 2. Volatile organic compounds with no available aquatic toxicity information

[IUPAC, International Union of Pure and Applied Chemistry]

IUPAC Compound Name	
	Target analytes
Bromodichloromethane	
Bromoethene	
Chloroethane	
Chloroethene	
Dichlorodifluoromethane	
1,1-Dichloroethane	
<i>cis</i> -1,2-Dichloroethene	
<i>cis</i> -1,3-Dichloropropene	
<i>trans</i> -1,3-Dichloropropene	
2-Ethoxy-2-methylpropane	
2-Methoxy-2-methylbutane	
1,1,2-Trichloro-1,2,2-trifluoroethane	
Trichlorofluoromethane	
	Other analytes
Bromobenzene	
Dibromomethane	
<i>trans</i> -1,4-Dichloro-2-butene	
2,2-Dichloropropane	
1,1-Dichloropropene	
1-Ethyl-2-methylbenzene	
Ethyl 2-methyl-2-propenoate	
Iodomethane	
2-Methyl-2-propenonitrile	
(1-Methylpropyl) benzene	
1,2,3,4-Tetramethylbenzene	
1,2,3,5-Tetramethylbenzene	
1,2,3-Trimethylbenzene	

Lowest Concentrations of Volatile Organic Compounds that Affect a Species

Some species are more sensitive to certain contaminants than others and are affected at lower concentrations. For this reason, aquatic toxicity information was reviewed for the lowest concentration that had any effect on any species. This information is summarized in table 3. Some compounds are acutely toxic to a species over a relatively narrow concentration range. When this occurs, the lowest concentration that affects the species is reported as a range rather than a single value.

Table 3. Lowest concentrations of volatile organic compounds that affect a species

[IUPAC, International Union of Pure and Applied Chemistry; when available, the lowest concentration is given in the following order of precedence: MATC, maximum-acceptable toxicant concentration; LOEC, lowest-observed effective concentration; EC₅₀, median effective concentration; LC₅₀, median lethal concentration; --, not reported; nv, no value; <, less than; >, greater than; endpoint effect: AVO, avoidance; BEH, behavior; BMS, biomass; CLR, chlorophyll; GRO, growth; IMM, immobilization; MOR, mortality, effect expressed as percentage of death; PSE, photosynthesis; PTR, phototactic response; REP, reproduction; TER, teratogenesis]

IUPAC compound name	Taxonomic classification	Genus, species/ Common name	Lowest concentration (micrograms per liter)				End-point effect	Duration of test (hours)
			MATC	LOEC	EC ₅₀	LC ₅₀		
Target analytes								
Benzene	fish	<i>Pimephales promelas</i> / Fathead minnow	nv	17,200	--	--	GRO	168
Bromomethane	fish	<i>Oryzias latipes</i> / Medaka, high-eyes	nv	nv	400	--	BEH	96
<i>n</i> -Butylbenzene	insects	<i>Daphnia magna</i> / Water flea	490	--	--	--	IMM	48
Chlorobenzene	insects	<i>Daphnia magna</i> / Water flea	nv	nv	585	--	IMM	48
Chloromethane	fish	<i>Lepomis macrochirus</i> / Bluegill	nv	nv	nv	550,000	MOR	96
Dibromochloromethane	fish	<i>Cyprinus carpio</i> / Common, mirror, colored, carp	nv	nv	nv	34,000	MOR	72-120
1,2-Dibromo-3-chloropropane	fish	<i>Lepomis macrochirus</i> / Bluegill	nv	nv	nv	20,000	MOR	48
1,2-Dibromoethane	fish	<i>Micropterus salmoides</i> / Largemouth bass	nv	nv	nv	15,000	MOR	24
1,2-Dichlorobenzene	insects	<i>Daphnia magna</i> / Water flea	nv	nv	550	--	REP	336
1,3-Dichlorobenzene	fish	<i>Oncorhynchus mykiss</i> / Rainbow trout, donaldson trout	555-1,040	--	--	--	GRO	768
1,4-Dichlorobenzene	fish	<i>Oncorhynchus mykiss</i> / Rainbow trout, donaldson trout	565-1,040	--	--	--	GRO	768
Dichlorobenzene (all isomers)	fish	<i>Brachydanio rerio</i> / Zebra danio, zebrafish	nv	nv	nv	10,000	MOR	48
1,2-Dichloroethane	fish	<i>Pimephales promelas</i> / Fathead minnow	29,000-59,000	--	--	--	GRO	768
1,1-Dichloroethene	plants	<i>Scenedesmus abundans</i> / Green algae	nv	nv	410,000	--	GRO	96
Dichloroethene (all isomers)	fish	<i>Lepomis macrochirus</i> / Bluegill	nv	nv	nv	140,000	MOR	96
<i>trans</i> -1,2-Dichloroethene	insects	<i>Daphnia magna</i> / Water flea	nv	nv	nv	220,000	MOR	48
Dichloromethane	amphibians	<i>Rana catesbeiana</i> / Bullfrog	nv	nv	17,780	--	TER	192
1,2-Dichloropropane	fish	<i>Pimephales promelas</i> / Fathead minnow	6,000-11,000	--	--	--	GRO	768
1,3-Dichloropropene	insects	<i>Daphnia magna</i> / Water flea	nv	nv	90	--	IMM	48

Table 3. Lowest concentrations of volatile organic compounds that affect a species—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ Common name	Lowest concentration (micrograms per liter)				End-point effect	Duration of test (hours)
			MATC	LOEC	EC ₅₀	LC ₅₀		
Target analytes—Continued								
1,2-Dimethylbenzene	fish	<i>Oncorhynchus kisutch</i> / Coho salmon, silver salmon	nv	nv	600	--	AVO	1
1,3-Dimethylbenzene	plants	<i>Selenastrum capricornutum</i> / Green algae	nv	nv	3,900	--	GRO	192
1,4-Dimethylbenzene	plants	<i>Selenastrum capricornutum</i> / Green algae	nv	nv	3,200	--	GRO	72
Dimethylbenzene (all isomers)	invertebrates, misc.	<i>Brachionus calyciflorus</i> / Rotifer	nv	40,000	--	--	REP	48
Ethenylbenzene	fish	<i>Oncorhynchus mykiss</i> / Rainbow trout, donaldson trout	nv	nv	nv	2,500	MOR	24
Ethylbenzene	insects	<i>Daphnia magna</i> / Water flea	nv	nv	1,810	--	IMM	24
1,1,2,3,4,4-Hexachloro-1,3-butadiene	fish	<i>Pimephales promelas</i> / Fathead minnow	6.5-13	--	--	--	GRO	768
1,1,1,2,2,2-Hexachloroethane	fish	<i>Oncorhynchus mykiss</i> / Rainbow trout, donaldson trout	67-207	--	--	--	GRO	768
2-Methoxy-2-methylpropane	fish	<i>Pimephales promelas</i> / Fathead minnow	nv	nv	nv	672,000	MOR	96
Methylbenzene	fish	<i>Pimephales promelas</i> / Fathead minnow	nv	6,000	--	--	GRO	768
(1-Methylethyl) benzene	insects	<i>Daphnia magna</i> / Water flea	nv	nv	601	--	IMM	48
Naphthalene	insects	<i>Daphnia magna</i> / Water flea	nv	nv	690	--	PTR	2
2,2-Oxybis[propane]	fish	<i>Pimephales promelas</i> / Fathead minnow	nv	nv	nv	91,700	MOR	96
2-Propenal	insects	<i>Daphnia magna</i> / Water flea	nv	nv	51	--	IMM	48
2-Propenenitrile	insects	<i>Daphnia magna</i> / Water flea	nv	nv	10,950	--	IMM	48
n-Propylbenzene	plants	<i>Selenastrum capricornutum</i> / Green algae	nv	nv	1,800	--	GPO	72
Tetrachloroethene	fish	<i>Oncorhynchus mykiss</i> / Rainbow trout, donaldson trout	500-1,400	--	--	--	GPO	768
Tetrachloromethane	fish	<i>Pimephales promelas</i> / Fathead minnow	52,100	--	--	--	MOR	168
Tribromomethane	plants	<i>Selenastrum capricornutum</i> / Green algae	nv	nv	38,600	--	CLR	96

Table 3. Lowest concentrations of volatile organic compounds that affect a species—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ Common name	Lowest concentration (micrograms per liter)				End-point effect	Duration of test (hours)
			MATC	LOEC	EC ₅₀	LC ₅₀		
Target analytes—Continued								
1,2,3-Trichlorobenzene	insects	<i>Daphnia magna</i> / Water flea	nv	nv	200	--	REP	336
1,2,4-Trichlorobenzene	fish	<i>Oncorhynchus mykiss</i> / Rainbow trout, donaldson trout	406	--	--	--	GRO	1,080
1,1,1-Trichloroethane	fish	<i>Pimephales promelas</i> / Fathead minnow	nv	nv	11,100	--	IMM	72
1,1,2-Trichloroethane	fish	<i>Oncorhynchus mykiss</i> / Rainbow trout, donaldson trout	6,000-14,800	--	--	--	GRO	768
Trichloroethene	fish	<i>Jordanella floridae</i> / Flagfish	nv	11,000	--	--	MOR	240
Trichloromethane	amphibians	<i>Hyla crucifer</i> / Spring peeper	nv	nv	270	--	TER	168
1,2,3-Trichloropropane	fish	<i>Pimephales promelas</i> / Fathead minnow	nv	nv	66,500	MOR	96	
1,2,4-Trimethylbenzene	insects	<i>Daphnia magna</i> / Water flea	nv	nv	3,600	--	IMM	48
Other analytes								
Bromochloromethane	fish	<i>Cyprinus carpio</i> / Common, mirror, colored, carp	nv	nv	nv	67,000	MOR	72-120
2-Butanone	insects	<i>Daphnia magna</i> / Water flea	nv	nv	5,091,000	--	IMM	48
Carbon disulfide	plants	<i>Chorella pyrenoidosa</i> / Green algae	nv	nv	21,000	--	GRO	96
1-Chloro-2-methylbenzene	insects	<i>Daphnia magna</i> / Water flea	nv	nv	20,000	--	IMM	24
1-Chloro-4-methylbenzene	fish	<i>Brachydanio rerio</i> / Zebra danio, zebrafish	nv	nv	nv	4,400	MOR	672
3-Chloro-1-propene	amphibians	<i>Xenopus laevis</i> / Clawed toad	nv	nv	nv	340	MOR	48
1,3-Dichloropropane	fish	<i>Pimephales promelas</i> / Fathead minnow	8,000-16,000	--	--	--	GRO	768
(1,1-Dimethylethyl)benzene	insects	<i>Daphnia magna</i> / Water flea	nv	nv	nv	41,000	MOR	24
1,4-Epoxybutane	fish	<i>Carassius auratus</i> / Goldfish	nv	nv	nv	2,400,000	MOR	48
Ethenylethanoate	fish	<i>Carassius auratus</i> / Goldfish	nv	nv	nv	42,330	MOR	24
2-Hexanone	fish	<i>Pimephales promelas</i> / Fathead minnow	nv	nv	nv	428,000	MOR	96
1-Isopropyl-4-methylbenzene	plants	<i>Skeletonema costatum</i> / Diatom	nv	nv	22,000	--	PSE	96

Table 3. Lowest concentrations of volatile organic compounds that affect a species—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ Common name	Lowest concentration (micrograms per liter)				End-point effect	Duration of test (hours)
			MATC	LOEC	EC ₅₀	LC ₅₀		
Other analytes—Continued								
Methyl 2-methyl-2-propenoate	fish	<i>Pimephales promelas</i> / Fathead minnow	nv	nv	nv	130,000	MCR	96
4-Methyl-2-pentanone	plants	<i>Scenedesmus subspicatus</i> / Green algae	nv	nv	980,000	--	BMS	48
Methyl-2-propenoate	fish	<i>Osteichthyes</i> / Bony fish class	nv	nv	nv	5,000	MCR	72
1,1'-Oxybisethane	fish	<i>Oryzias latipes</i> / Medaka, high-eyes	nv	nv	nv	>1,000,000	MCR	24
2-Propanone	insects	<i>Daphnia magna</i> / Water flea	>1,103,200- <2,206,400	--	--	--	MCR	672
1,1,1,2-Tetrachloroethane	fish	<i>Lepomis macrochirus</i> / Bluegill	nv	nv	nv	20,000	MCR	24
1,1,2,2-Tetrachloroethane	fish	<i>Oncorhynchus mykiss</i> / Rainbow trout, donaldson trout	1,400-4,000	--	--	--	GRO	768
1,3,5-Trimethylbenzene	insects	<i>Daphnia magna</i> / Water flea	nv	nv	6,011	--	IMM	48

WATER-QUALITY CRITERIA AND GUIDELINES FOR VOLATILE ORGANIC COMPOUNDS

Water-quality criteria and guidelines for 39 VOCs (table 4) measured by the USGS have been established by USEPA (U.S. Environmental Protection Agency, 1996a) and Canada (Canadian Council of Resource and Environment Ministers, 1991) to protect freshwater biota. When toxicity information is insufficient to develop criteria, USEPA uses values equal to the LOEC. Canadian water-quality guidelines, which are nonenforceable guidelines that may provide the basis for Provincial Standards or Objectives (Richard Aucoin, Environment Canada, oral commun., 1997) are lower than the USEPA criteria. This may be attributed to procedures for determining the values. Canadian Water-Quality Guidelines, which *** are set at such values as to protect all forms of aquatic life and all aspects of the aquatic life cycles" (Canadian Council of Resource and Environment Ministers, 1991), contrasts with the USEPA approach in which " *** protection of all species at all times and places is not deemed necessary" (Stephan and others, 1985). Canadian guidelines are derived from the most sensitive of the

following: (1) "no negative effect" data obtained from life-stage tests of chronic toxicity; (2) thresholds for the tainting of fish flesh; or (3) concentrations in the water that would result in acceptable concentrations in the edible portions of marketable fish (or the protection of natural consumers). If sufficient chronic toxicity data are not available, Canadian guidelines are based on short-term toxicity data (96 hour LC₅₀) of the most sensitive species multiplied by application factors of 0.05 for nonpersistent effects and 0.01 for persistent effects.

The USEPA's aquatic-life criteria are nonenforceable scientific recommendations that may provide the basis for State standards. Acute and chronic criteria issued under the 1985 guidelines (Stephan and others, 1985) are the criterion maximum concentration (CMC) and the criterion continuous concentration (CCC), respectively. The acute and chronic criteria are based on the highest concentration of a pollutant that freshwater aquatic organisms can be exposed to for an established period of time without deleterious effects—1 hour for CMC and 4 days for CCC. Water-quality criteria are based on guidelines established using extensive data requirements and complex mathematical derivations.

Table 4. Water-quality criteria and guidelines for volatile organic compounds

[IUPAC, International Union of Pure and Applied Chemistry; USEPA, U.S. Environmental Protection Agency; all values are in micrograms per liter;
--, criteria does not exist]

IUPAC compound name	USEPA freshwater acute criteria/guidelines ¹	USEPA freshwater chronic criteria/guidelines ¹	Canadian water-quality guidelines ²
Target analytes			
Benzene	5,300	--	300
Bromodichloromethane	11,000	--	--
Bromomethane	11,000	--	--
Chlorobenzene	250	50	15
Chloroethane	³ 860,000	⁴ 230,000	--
Dibromochloromethane	11,000	--	--
1,2-Dichlorobenzene	1,120	763	2.5
1,3-Dichlorobenzene	1,120	763	2.5
1,4-Dichlorobenzene	--	--	4
Dichlorodifluoromethane	11,000	--	--
1,2-Dichloroethane	118,000	20,000	100
1,1-Dichloroethene	11,600	--	--
<i>cis</i> -1,2-Dichloroethene	11,600	--	--
<i>trans</i> -1,2-Dichloroethene	11,600	--	--
Dichloromethane	11,000	--	98
<i>cis</i> -1,3-Dichloropropene	6,600	244	--
<i>trans</i> -1,3-Dichloropropene	6,600	244	--
Ethylbenzene	32,000	--	90
1,1,2,3,4,4-Hexachloro-1,3-butadiene	90	9.3	.1
1,1,1,2,2,2-Hexachloroethane	980	540	--
Methylbenzene	17,500	--	2
Naphthalene	2,300	620	--
2-Propenal	68	21	1,000
2-Propenenitrile	7,550	2,600	--
Tetrachloroethene	--	--	110
Tetrachloromethane	35,200	--	13
Tribromomethane	11,000	--	--
1,2,3-Trichlorobenzene	--	--	.9
1,2,4-Trichlorobenzene	250	50	.5
1,1,1-Trichloroethane	18,000	--	--
1,1,2-Trichloroethane	18,000	9,400	--
Trichloroethene	45,000	21,900	20
Trichlorofluoromethane	11,000	--	--
Trichloromethane	28,900	1,240	2
Other analytes			
Bromochloromethane	11,000	--	--
Carbon disulfide	--	2	--
3-Chloro-1-propene	³ 860,000	⁴ 230,000	--
1,1,1,2-Tetrachloroethane	9,320	--	--
1,1,2,2-Tetrachloroethane	9,320	2,400	--

¹U.S. Environmental Protection Agency, 1996b.²Canadian Council of Resource and Environment Ministers, 1991.³1-hour average, freshwater acute water-quality criteria.⁴4-day average, freshwater chronic water-quality criteria.

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AQUATIC TOXICITY INFORMATION

EXPLANATION OF TERMS USED IN TABLE 5

IUPAC compound name: (International Union of Pure and Applied Chemistry) Internationally recognized system of accepted chemical names.

Taxonomic classification: Represented by phylum, class, order, genus, species, and so forth.

n: Total number of studies that used the chemical on a designated genus/species. Includes only studies with acceptable experimental design; that is, freshwater only and documentation codes C and M. The lowest effective concentration of a specified compound is listed first, and if data are available, the second lowest concentration is also recorded. The second lowest number may be from the same cited reference as the lowest number, or it may be from a different study conducted within the same experimental parameters (see "Documentation Codes" and "Endpoint Effect Codes" below).

Duration: Length of exposure is coded in time units (that is, hours), depending on the species. For a fluctuating or intermittent dosing experiment, the total exposure time is recorded.

Measures of toxicity:

(<, less than; >, greater than) see MATC definitions, this page.

LC₅₀: (Median Lethal Concentration) Statistically estimated concentration that is expected to be lethal to 50 percent of a group of organisms tested after an exposure time—24–96 hours or less.

EC₅₀: (Median Effective Concentration) Effective concentration for 50 percent of the organisms tested. Used when an effect other than death is the observed endpoint.

LOEC: (Lowest-Observed Effective Concentration) The lowest concentration producing a statistically significant effect.

MATC: (Maximum-Acceptable Toxicant Concentration) Hypothetical toxic concentration lying in a range bounded at the lower end by the highest tested concentration having no-observed effect (NOEC) and at the higher end by the lowest tested concentration having a significant toxic effect (LOEC) in a life cycle (full chronic) or partial cycle (partial chronic) test. NOEC < MATC < LOEC.

NOEC: (No-Observed Effective Concentration) The highest concentration at which observed effects are not found or are not statistically significant.

Endpoint Effect Codes denoted by the following: **ABN**=abnormality; **AVO**=avoidance; **BEH**=behavior; **BMS**=biomass; **CLR**=chlorophyll; **CYT**=cytogenetic; **DET**=detachment; **ENZ**=enzyme; **EQU**=equilibrium, change in ability to maintain balance; **FOC**=food consumption; **GRO**=growth; **HAT**=hatchability, change in percentage of hatch, time to hatch number of eggs hatched; **IMM**=immobilization; **IRR**=irritation; **LOC**=locomotor behavior; **MIG**=migration; **MOR**=mortality, effect expressed as a percentage of death; **NR**=no response; **PGR**=population growth; **PRB**=predatory behavior; **PRV**=predatory vulnerability; **PSE**=photosynthesis; **REP**=reproduction; **RGN**=regeneration; **STR**=stress; **SVC**=shell valve closure; **TER**=teratogenesis; **THL**=thermal.

DC: (Documentation Code) **DC=C:** (Complete) meets the following criteria: methodology section cites published or well-documented procedures; satisfactory control; toxicant concentration measured; for organic and nonmetallic inorganic chemicals, the test water temperature, pH, and dissolved oxygen are reported; alkalinity or hardness are reported. **DC=M:** (Moderate) procedures generally satisfactory; that is, followed some standard methods but one or more of the following pieces of information are missing or incomplete: control mortality, solvent control when a solvent is used in the test, toxicant concentration, test water chemistry.

Source no.: Number assigned to a study, indicating the reference where information was found. Number may be used to retrieve citation from AQUIRE data base (U.S. Environmental Protection Agency, 1996a). Full citations are listed by source numbers in table 6.

..: Indicates unavailable data or designates space for which toxicity data are addressed in a separate column.

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey

[Information was retrieved from U.S. Environmental Protection Agency's data base, AQURE. A number of studies using the same species, duration, and endpoint were available for some VOCs. In these instances, only the two studies that reported the lowest concentration that had an effect were included in the compilation]

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Target analytes	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.	
						EC ₅₀	LC ₅₀	LOEC	MATC	NOEC			
Benzene	amphibians	<i>Ambystoma mexicanum/</i> Mexican axolotl	1	48	370,000	--	--	--	--	--	MOR	M	9740
	amphibians	<i>Xenopus laevis/</i> Clawed toad	2	48	190,000	--	--	--	--	--	MOR	M	12152
	crustaceans	<i>Diaptomus forbesi/</i> Calanoid copepod	1	96	710,000	--	--	--	--	--	MOR	M	11282
	crustaceans	<i>Gammarus fossarum/</i> Scud	5	120	66,007	--	--	--	--	--	MOR	M	13419
	crustaceans	<i>Gammarus pulex/</i> Scud	1	48	42,000	--	--	--	--	--	MOR	M	13419
	fish	<i>Carassius auratus/</i> Goldfish	4	24	34,420	--	--	--	--	--	MOR	C	728
	fish	<i>Cottus cognatus/</i> Slimy sculpin	1	96	13,541	--	--	--	--	--	MOR	C	728
	fish	<i>Gambusia affinis/</i> Mosquitofish	3	96	386,000	--	--	--	--	--	MOR	C	508
	fish	<i>Gasterosteus aculeatus/</i> Three spine stickleback	1	96	21,818	--	--	--	--	--	MOR	M	508
	fish	<i>Ictalurus punctatus/</i> Channel catfish	1	96	425,000	--	--	--	--	--	MOR	C	666
	fish	<i>Lepomis macrochirus/</i> Bluegill	6	24	20,000	--	--	--	--	--	MOR	C	922
	fish	<i>Oncorhynchus gorbuscha/</i> Pink salmon	3	96	4,640	--	--	--	--	--	MOR	C	922
	fish	<i>Oncorhynchus kisutch/</i> Coho salmon, silver salmon	3	96	15,017	--	--	--	--	--	MOR	M	5622
	fish	<i>Oncorhynchus kisutch/</i> Coho salmon, silver salmon	96	96	8,611	--	--	--	--	--	MOR	M	5622
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	5	96	12,381	--	--	--	--	--	MOR	M	5622
	fish	<i>Oncorhynchus nerka/</i> Sockeye salmon	1	96	1,740	--	--	--	--	--	MOR	C	15131
	fish	<i>Oncorhynchus tshawytscha/</i> Chinook salmon	1	96	1,750	--	--	--	--	--	MOR	M	15211
					9,455	--	--	--	--	--	MOR	M	13142
					10,307	--	--	--	--	--	MOR	M	5622

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC			
Target analytes—Continued											
Benzene—Continued	fish	<i>Oryzias latipes/</i> Medaka, high-eyes	7	24	54,000	--	--	--	--	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	12	96	54,000	--	--	--	--	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	168	168	--	12,600	--	--	--	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	2	168	--	14,010	--	--	--	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	168	168	--	262	--	--	--	BMS	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	2	168	--	171	--	--	--	GRO	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	168	168	--	17,200	--	--	--	GRO	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	2	168	--	17,200	--	--	--	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	168	168	--	10,200	--	--	--	GRO	M
	fish	<i>Poecilia reticulata/</i> Guppy	4	96	28,600	--	--	--	--	MOR	M
	fish	<i>Salmo trutta/</i> Brown trout	1	1	36,600	--	--	--	--	MOR	C
	fish	<i>Salvelinus malma/</i> Dolly varden	2	96	12,000	--	--	--	--	MOR	C
	fish	<i>Thymallus arcticus/</i> Arctic grayling	96	96	10,457	--	--	--	--	MOR	M
insects		<i>Aedes aegypti/</i> Mosquito	1	96	10,509	--	--	--	--	MOR	M
insects		<i>Aedes aegypti/</i> Mosquito	1	48	12,926	--	--	--	--	MOR	M
insects		<i>Aedes aegypti/</i> Mosquito	1	48	200,000	--	--	--	--	MOR	M
insects		<i>Aedes aegypti/</i> Mosquito	1	24	59,270	--	--	--	--	IMM	M
insects		<i>Aeolus aquaticus/</i> Aquatic sowbug	6	48	120,000	--	--	--	--	MOR	M
insects		<i>Chironomidae/</i> Midge family	120	120	284,511	--	--	--	--	MOR	M
insects		<i>Chironomus thummi/</i> Midge	1	96	1,370,000	--	--	--	--	IMM	M
insects		<i>Cloeon dipterum/</i> Mayfly	48	48	100,000	--	--	--	--	MOR	M
insects		<i>Corixia punctata/</i> Water boatman	48	48	34,000	--	--	--	--	MOR	M
insects		<i>Culex pipiens/</i> Mosquito	71,000	71,000	--	--	--	--	--	MOR	M

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n (hours)	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC			
Target analytes—Continued											
Benzene—Continued	insects	<i>Daphnia cucullata/</i> Water flea	2	48	356,000	--	--	--	--	MOR	M
	insects	<i>Daphnia magna/</i> Water flea	10	48	390,000	--	--	--	--	MOR	M
	insects	<i>Daphnia magna/</i> Water flea	6	1	250,000	--	--	--	--	MOR	C
	insects	<i>Daphnia pulex/</i> Water flea	3	24	--	6,300	--	--	--	ENZ	M
	insects	<i>Ischnura elegans/</i> Dragonfly	1	48	15,000	--	--	--	--	IMM	M
	insects	<i>Nemoura cinerea/</i> Stonefly	1	48	265,000	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Amphimelania holandri/</i> Snail	5	120	130,000	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Brachionus calyciflorus/</i> Rotifer	2	96	671,446	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Dugesia lugubris/</i> Turbellarian, flatworm	24	24	819,392	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Erpobdella octoculata/</i> Leech	1	48	>1,000	--	--	--	--	MOR	C
	invertebrates, misc.	<i>Hydra oligactis/</i> Hydra	1	48	>1,000,000	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Lymnaea stagnalis/</i> Great pond snail	7	48	74,000	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Oligochaeta (order)/</i> <i>Tubificidae (family)</i>	1	48	>320,000	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Viviparus bengalensis/</i> Snail	2	48	>320,000	--	--	--	--	MOR	M
plants	plants	<i>Chlorella vulgaris/</i> Green algae	1	96	34,000	--	--	--	--	MOR	M
plants	plants	<i>Scenedesmus abundans/</i> Green algae	1	24	34,000	--	--	--	--	MOR	M
plants	plants	<i>Selenastrum capricornutum.../</i> Green algae	2	72	230,000	--	--	--	--	GRO	M
	plants		192	1	230,000	--	--	--	--	GRO	M
	plants		192	96	41,000	--	--	--	--	GRO	M
	plants		192	2	29,000	--	--	--	--	GRO	M
	plants		192	1	>1,360,000	--	--	--	--	GRO	M

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)					End-point effect	DC	Source no.		
					LC ₅₀	EC ₅₀	LOEC	MATC	NOEC					
Target analytes—Continued														
Bromomethane	fish	<i>Cyprinus carpio/</i> Common, mirror, colored, carp <i>Lepomis macrochirus/</i> Bluegill	1	96	11,000	--	--	--	--	--	MOR	M	10516	
	fish	<i>Oryzias latipes/</i> Medaka, high-eyes	3	96	700	--	--	--	--	--	MOR	C	863	
	fish	<i>Oryzias latipes/</i> Medaka, high-eyes	4	96	--	400	--	--	--	--	BEH	C	5331	
	fish	<i>Oryzias latipes/</i> Medaka, high-eyes	24	--	500	--	--	--	--	--	BEH	C	5331	
	fish	<i>Oryzias latipes/</i> Medaka, high-eyes	4	2,191	--	--	--	--	--	--	320	BEH	6059	
	fish	<i>Poecilia reticulata/</i> Guppy	4	96	0.800	--	--	--	--	--	320	GRO	6059	
	fish	<i>Poecilia reticulata/</i> Guppy	8	96	--	0.600	--	--	--	--	IMM	C	5331	
	fish	<i>Poecilia reticulata/</i> Guppy	72	--	0.800	--	--	--	--	--	IMM	C	5331	
	fish	<i>Daphnia magna/</i> Water flea	2	504	--	--	--	--	--	--	100	BEH	M	6059
	insects	<i>Daphnia magna/</i> Water flea	504	--	--	--	--	--	--	--	320	MOR	M	6059
	insects	<i>Daphnia magna/</i> Water flea	1	48	2,200	--	--	--	--	--	MOR	C	5331	
	insects	<i>Daphnia magna/</i> Water flea	2	48	--	1,700	--	--	--	--	BEH	C	5331	
	plants	<i>Chlorella pyrenoidosa/</i> Green algae	2	48	--	2,000	--	--	--	--	IMM	C	5331	
	plants	<i>Scenedesmus quadricauda/</i> Green algae	2	24	--	5,000	--	--	--	--	GRO	C	5331	
	insects	<i>Daphnia magna/</i> Water flea	8	48	--	2,100-6,700	--	--	--	--	IMM	C	5331	
	insects	<i>Daphnia magna/</i> Water flea	1	48	--	340	--	--	--	--	IMM	C	6984	
	fish	<i>Brachydanio rerio/</i> Zebra danio, zebrafish	2	48	--	380	--	--	--	--	490	--	6984	
	fish	<i>Brachydanio rerio/</i> Zebra danio, zebrafish	4	168	--	--	--	--	--	--	--	MOR	M	3279
	fish	<i>Carassius auratus/</i> Goldfish	11	180	880	--	--	--	--	--	8,500	REP	M	15526
			192	880	--	--	--	--	--	--	8,500	REP	M	3279
					--	--	--	--	--	--	MOR	C	538	
					--	--	--	--	--	--	MOR	C	563	

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	NOEC		
Target analytes—Continued										
Chlorobenzene—Continued	fish	<i>Lepomis macrochirus/</i> Bluegill	19	24	4,500	--	--	--	--	MOR C
	fish	<i>Micropterus salmoides/</i> Largemouth bass	8	156	50	--	--	--	--	MOR C
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	5	384	<90	--	--	--	--	MOR C
	fish	<i>Pimephales promelas/</i> Fathead minnow	13	96	16,900	--	--	--	--	MOR C
	fish	<i>Poecilia reticulata/</i> Guppy	4	24	5,630	--	--	--	--	MOR M
	insects	<i>Ceriodaphnia dubia/</i> Water flea	10	48	7,900	--	--	--	--	MOR C
	insects	<i>Ceriodaphnia dubia/</i> Water flea	3	168-240	--	14,000	--	--	--	MOR C
	insects	<i>Ceriodaphnia dubia/</i> Water flea	168-240	--	22,000	--	--	--	--	MOR C
	insects	<i>Ceriodaphnia dubia/</i> Water flea	4	168-240	--	--	--	--	3,890	MOR M
	insects	<i>Chironomus riparius/</i> Midge	1	96-98	--	--	--	--	12,000	REP M
	insects	<i>Daphnia magna/</i> Water flea	13	48	8,600	--	--	--	720	BEH C
	insects	<i>Daphnia magna/</i> Water flea	8	48	10,700	--	--	--	--	MOR C
	insects	<i>Daphnia magna/</i> Water flea	336	--	585	--	--	--	--	IMM M
	insects	<i>Daphnia magna/</i> Water flea	4	216-264	--	2,500	--	--	--	REP M
	plants	<i>Cyclotella meneghiniana/</i> Diatom	216-264	--	--	--	--	--	6,500	REP M
	plants	<i>Selenastrum capricornutum/</i> Green algae	1	48	--	235,740	--	--	11,000	REP M
	plants	<i>Selenastrum capricornutum/</i> Green algae	4	96	--	202,000	--	--	--	PGR M
	plants	<i>Selenastrum capricornutum/</i> Green algae	96	--	210,000	--	--	--	<100,000	CLR M
Chloromethane	fish	<i>Lepomis macrochirus/</i> Bluegill	1	96	550,000	--	--	--	--	MOR C
1,2-Dibromo-3-chloropropane	fish	<i>Lepomis macrochirus/</i> Bluegill	3	48	20,000	--	--	--	--	MOR C
	fish	<i>Micropterus salmoides/</i> Largemouth bass	3	24	50,000	--	--	--	--	MOR C
				48	20,000	--	--	--	--	MOR C
				24	30,000	--	--	--	--	MOR C

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)						End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC	NOEC				
Target analytes—Continued													
1,2-Dibromo-3-chloropropane—Continued	invertebrates, misc.	<i>Cipangopaludina malleata/</i> Mud snail	1	48	53,000	--	--	--	--	--	MOR	M	9158
	invertebrates, misc.	<i>Indoplanorbis exustus/</i> Snail	1	48	57,000	--	--	--	--	--	MOR	M	9158
	invertebrates, misc.	<i>Physa acuta/</i> Bladder snail	1	48	24,000	--	--	--	--	--	MOR	M	9158
	invertebrates, misc.	<i>Semisulcospira libertina/</i> Marsh snail	1	48	50,000	--	--	--	--	--	MOR	M	9158
Dibromochloromethane	fish	<i>Cyprinus carpio/</i> Common, mirror, colored, carp	2	72-120	34,000	--	--	--	--	--	MOR	M	6360
1,2-Dibromoethane	fish	<i>Lepomis macrochirus/</i> Bluegill	3	24	18,000	--	--	--	--	--	MOR	M	6360
	fish	<i>Micropodus salmoides/</i> Largemouth bass	3	24	15,000	--	--	--	--	--	MOR	C	2786
	fish	<i>Brachydanio rerio/</i> Zebra danio, zebrafish	1	48	6,800	--	--	--	--	--	MOR	C	2786
	fish	<i>Lepomis macrochirus/</i> Bluegill	3	96	5,600	--	--	--	--	--	MOR	C	5590
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	7	144	1,540	--	--	--	--	--	MOR	C	5590
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	96	--	1,550	--	--	--	--	MOR	C	10579
	fish	<i>Pimephales promelas/</i> Fathead minnow	8	96	6,027	--	--	--	--	--	MOR	M	7257
	fish	<i>Poecilia reticulata/</i> Guppy	1	96	4,792	--	--	--	--	--	MOR	C	12858
insects		<i>Daphnia Magna/</i> Water flea	3	24	2,400	--	--	--	--	--	MOR	C	5184
insects		<i>Daphnia magna/</i> Water flea	6	336	--	550	--	--	--	--	REP	M	15526
insects		<i>Daphnia magna/</i> Water flea	1	504	--	780	--	--	--	--	IMM	M	15526
insects		<i>Tanytarsus dissimilis/</i> Midge	2	48	12,000	--	--	--	--	--	REP	M	847
				24	19,900	--	--	--	--	--	MOR	C	10579
						--	--	--	--	--	MOR	C	10579

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.		
					LC ₅₀	EC ₅₀	LOEC	NOEC					
Target analytes—Continued													
1,2-Dichlorobenzene—Continued	plants	<i>Cyclotella meneghiniana/</i> Diatom	1	48	—	23,330	—	—	—	CYT	C	88	
	plants	<i>Scenedesmus subspicatus/</i> Green algae	2	48	—	13,500	—	—	—	GRO	M	2997	
	plants	<i>Selenastrum capricornutum/</i> Green algae	5	24	—	14,000	—	—	—	BMS	M	2997	
	plants	<i>Selenastrum capricornutum/</i> Green algae	96	96	—	65,800	—	—	—	CLR	M	9607	
	plants	<i>Selenastrum capricornutum/</i> Green algae	1	96	—	71,100	—	—	—	CLR	M	9607	
									<10,000	CLR	M	9607	
1,3-Dichlorobenzene	fish	<i>Lepomis macrochirus/</i> Bluegill	2	96	5,000	—	—	—	—	MOR	C	5590	
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	2	768	—	—	—	—	555-1,040	—	GRO	C	4433
	fish	<i>Pimephales promelas/</i> Fathead minnow	3	96	7,800	—	—	—	555-1,040	—	MOR	C	4433
	fish	<i>Pimephales promelas/</i> Fathead minnow	1	768	—	—	—	—	—	MOR	C	10183	
	fish	<i>Pimephales promelas/</i> Fathead minnow	1	96	—	—	—	—	—	MOR	C	12124	
	fish	<i>Pimephales promelas/</i> Fathead minnow	1	768	—	—	—	—	—	MOR	M	12124	
	fish	<i>Pimephales promelas/</i> Fathead minnow	1	96	—	—	—	—	1,500	—	MOR	C	12124
	fish	<i>Pimephales promelas/</i> Fathead minnow	1	768	—	—	—	—	—	1,000	MOR	M	12124
	insects	<i>Chironomus riparius/</i> Midge	1	96-98	—	—	—	—	—	37	BEH	C	14176
	insects	<i>Daphnia magna/</i> Water flea	5	48	1,700	—	—	—	—	MOR	M	5675	
	insects	<i>Daphnia magna/</i> Water flea	5	384	7,200	—	—	—	—	MOR	C	15981	
	insects	<i>Daphnia magna/</i> Water flea	2	48	—	1,400	—	—	—	REP	M	5675	
	plants	<i>Cyclotella meneghiniana/</i> Diatom	1	504	—	4,200	—	—	—	IMM	C	15981	
	plants	<i>Scenedesmus subspicatus/</i> Green algae	2	384	—	—	—	—	—	300	GRO	C	12872
	plants	<i>Selenastrum capricornutum/</i> Green algae	5	96	—	—	—	—	500	REP	C	847	
	plants	<i>Selenastrum capricornutum/</i> Green algae	72	96	—	—	—	—	—	CYT	C	88	

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC			
Target analytes—Continued											
1,4-Dichlorobenzene	fish	<i>Brachydanio rerio/</i> Zebra danio, zebrafish	3	672	2,700	--	--	--	--	MOR	M
	fish	<i>Brachydanio rerio/</i> Zebra danio, zebrafish	4	168	4,200	--	--	--	--	MOR	M
	fish	<i>Jordanella floridae/</i> Flagfish	7	72	2,053	--	--	--	--	2,100 REP	M
	fish	<i>Jordanella floridae/</i> Flagfish	3	240	--	--	--	--	2,100 REP	M	3279
	fish	<i>Lepomis macrochirus/</i> Bluegill	2	96	4,300	--	--	--	--	MOR	M
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	8	336	800	--	--	--	--	MOR	M
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	96	1,120	--	--	--	--	MOR	M
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	2	768	--	--	--	--	--	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	14	96	2,400	--	--	--	--	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	1	768	2,852	--	--	--	--	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	1	96	--	--	--	--	--	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	2	96	--	--	--	--	565-1,040	GRO	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	1	168	--	--	--	--	565-1,040	MOR	C
	fish	<i>Poecilia reticulata/</i> Guppy	1	96	2,896	--	--	--	--	MOR	M
insects		<i>Chironomus riparius/</i> Midge	1	48	12,000	--	--	--	--	MOR	M
insects		<i>Chironomus riparius/</i> Midge	1	48	--	--	--	--	940 MOR	M	4072
insects		<i>Daphnia magna/</i> Water flea	2	48	11,000	--	--	--	--	MOR	C
insects		<i>Daphnia magna/</i> Water flea	4	336	42,000	--	--	--	--	REP	M
				24	930	--	--	--	--	IMM	M
				24	1,600	--	--	--	--	IMM	M
											10712

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)						DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC	NOEC	End-point effect		
Target analytes—Continued												
1,4-Dichlorobenzene—Continued	insects	<i>Daphnia magna</i> / Water flea	1	504	--	--	--	--	--	300 REP	M	847
	insects	<i>Tanytarsus dissimilis</i> / Midge	2	48	13,000 22,100	--	--	--	--	-- MOR	C	10579
	plants	<i>Cyclotella meneghiniana</i> / diatom	1	48	--	34,300	--	--	--	-- CYT	C	10579
	plants	<i>Scedesmus subspicatus</i> / Green algae	2	48	--	28,000	--	--	--	-- BMS	M	2997
	plants	<i>Selenastrum capricornutum</i> / Green algae	7	96	--	38,000	--	--	--	-- GRO	M	2997
	plants	<i>Selenastrum capricornutum</i> / Green algae	3	3	--	1,600	--	--	--	-- GRO	M	10712
	plants	<i>Selenastrum capricornutum</i> / Green algae	1	96	--	5,200	--	--	--	-- PSE	M	10712
1,2-Dichloroethane	amphibians	<i>Ambystoma gracile</i> / Salamander	2	228	2,540	--	--	--	--	-- MOR	C	15418
	amphibians	<i>Rana pipiens</i> / Leopard frog	2	216	6,530	--	--	--	--	-- MOR	C	15418
	crustaceans	<i>Gammarus fasciatus</i> / Scud	1	120	4,400	--	--	--	--	-- MOR	C	15418
	fish	<i>Oncorhynchus mykiss</i> / Rainbow trout, donaldson trout	1	672	4,520	--	--	--	--	-- MOR	C	15418
	fish	<i>Oryzias latipes</i> / Medaka, high-eyes	6	24	116,000	--	--	--	--	-- MOR	M	12497
	fish	<i>Pimephales promelas</i> / Fathead minnow	5	72	116,000	--	--	--	--	-- MOR	C	12497
	fish	<i>Pimephales promelas</i> / Fathead minnow	96	768	116,000	--	--	--	--	-- MOR	C	11227
	insects	<i>Daphnia magna</i> / Water flea	6	24	220,000	--	--	--	--	-- GRO	C	11227
	insects	<i>Pteronarcys californica</i> / Stonefly	1	96	>100,000	--	--	--	--	-- MOR	C	15301
1,1-Dichloroethene	insects	<i>Daphnia magna</i> / Water flea	5	48	250,000	--	--	--	--	-- MOR	C	5184
	fish	<i>Lepomis macrochirus</i> / Bluegill	3	24	160,000	--	--	--	--	-- MOR	C	5184
	fish	<i>Pimephales promelas</i> / Fathead minnow	15	96	180,000	--	--	--	--	-- MOR	C	666
			192	74,000	74,000	--	--	--	--	-- MOR	C	15981
				29,000	29,000	--	--	--	--	-- MOR	C	15981
				29,000	29,000	--	--	--	--	-- MOR	C	5590
				29,000	29,000	--	--	--	--	-- MOR	C	5590
				29,000	29,000	--	--	--	--	-- MOR	C	5741
				29,000	29,000	--	--	--	--	-- MOR	C	5741

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	NOEC			
Target analytes—Continued											
1,1-Dichloroethene—Continued	insects	<i>Daphnia magna</i> / Water flea	4	24	11,600	--	--	--	--	MOR	C
	plants	<i>Scenedesmus abundans</i> / Green algae	1	96	48	410,000	--	--	--	MOR	C
	plants	<i>Selenastrum capricornutum</i> / Green algae	5	24	--	>560,000	--	--	--	GRO	M
	plants	<i>Selenastrum capricornutum</i> / Green algae	1	96	48	>560,000	--	--	--	CLR	M
										CLR	M
										<26,000	CLR
											M
											9607
											9607
											9607
<i>trans</i> -1,2-Dichloroethene	insects	<i>Daphnia magna</i> / Water flea	2	48	220,000	--	--	--	--	MOR	C
Dichloromethane	amphibians	<i>Bufo woodhousei fowleri</i> / Fowler's toad	2	24	230,000	--	--	--	--	MOR	C
	amphibians	<i>Rana catesbeiana</i> / Bullfrog	2	72	--	>32,000	--	--	--	TER	C
	amphibians	<i>Rana palustris</i> / Pickerel frog	96	168	--	>32,000	--	--	--	TER	C
	fish	<i>Carassius auratus</i> / Goldfish	2	192	--	17,780	--	--	--	TER	C
	fish	<i>Lepomis macrochirus</i> / Bluegill	96	96	--	30,610	--	--	--	TER	C
	fish	<i>Oryzias latipes</i> / Medaka, high-eyes	2	8	--	>32,000	--	--	--	TER	C
	fish	<i>Pimephales promelas</i> / Fathead minnow	96	96	--	>32,000	--	--	--	TER	C
	fish	<i>Pimephales promelas</i> / Fathead minnow	1	24	420,000	--	--	--	--	MOR	M
	insects	<i>Daphnia magna</i> / Water flea	2	48	220,000	--	--	--	--	MOR	C
	insects	<i>Daphnia magna</i> / Water flea	3	48	24	230,000	--	--	--	MOR	C
	plants	<i>Lemna minor</i> / Duckweed	1	<504	48	310,000	--	--	--	GRO	M
											3881

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	NOEC			
Target analytes—Continued											
Dichloromethane—Continued	plants	<i>Selenastrum capricornutum/</i> Green algae	5	24	>500,000	>500,000	—	—	—	CLR	M
	plants	<i>Selenastrum capricornutum/</i> Green algae	1	96	—	—	—	—	—	CLR	M
1,2-Dichloropropane	fish	<i>Lepomis macrochirus/</i> Bluegill	3	96	280,000	320,000	—	—	—	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	5	96	127,000	140,000	—	—	—	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	1	768	—	—	—	—	6,000- 11,000	GRO	C
	insects	<i>Daphnia magna/</i> Water flea	2	48	52,000	—	—	—	—	MOR	C
1,2-Dimethylbenzene	amphibians	<i>Xenopus laevis/</i> Clawed toad	1	48	99,000	73,000	—	—	—	MOR	C
	fish	<i>Carassius auratus/</i> Goldfish	2	24	13,000	16,100	—	—	—	MOR	C
	fish	<i>Catostomus commersonii/</i> White sucker	1	96	16,100	—	—	—	—	MOR	C
	fish	<i>Lepomis macrochirus/</i> Bluegill	1	96	16,100	—	—	—	—	MOR	C
	fish	<i>Oncorhynchus kisutch/</i> Coho salmon, silver salmon	2	1	—	—	600	—	—	AVO	M
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	2	96	7,600	8,050	—	—	—	AVO	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	3	96	16,100	16,400	—	—	—	MOR	M
	fish	<i>Poecilia reticulata/</i> Guppy	1	96	12,000	—	—	—	—	MOR	C
	insects	<i>Daphnia magna/</i> Water flea	3	24	—	—	1,000	—	—	IMM	M
	invertebrates, misc.	<i>Aploxa hypnorum/</i> Snail	1	96	—	>22,400	3,185	—	—	IMM	C
	plants	<i>Chlorella vulgaris</i> Green algae	1	24	—	—	55,000	—	—	MOR	C
	plants	<i>Selenastrum capricornutum/</i> Green algae	2	192	—	—	4,200	—	—	GRO	M
			2	72	—	—	4,700	—	—	GRO	M

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Target analytes—Continued			Measures of toxicity (micrograms per liter)			End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC	NOEC				
1,3-Dimethylbenzene													
fish		<i>Carassius auratus/</i> Goldfish	1	24	16,000	--	--	--	--	--	MOR	C	623
fish		<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	96	8,400	--	--	--	--	--	MOR	M	13142
fish		<i>Pimephales promelas/</i> Fathead minnow	1	96	16,000	--	--	--	--	--	MOR	C	3217
fish		<i>Poecilia reticulata/</i> Guppy	1	96	12,900	--	--	--	--	--	MOR	M	13142
insects		<i>Daphnia magna/</i> Water flea	2	24	--	4,700	--	--	--	--	IMM	M	13142
plants		<i>Selenastrum capricornutum/</i> Green algae	2	192	--	9,556	--	--	--	--	IMM	C	11936
fish		<i>Carassius auratus/</i> Goldfish	1	72	--	3,900	--	--	--	--	GRO	M	3550
fish		<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	24	18,000	--	4,900	--	--	--	GRO	M	13142
fish		<i>Poecilia reticulata/</i> Guppy	1	96	2,600	--	--	--	--	--	MOR	C	623
insects		<i>Daphnia magna/</i> Water flea	3	24	--	8,800	--	--	--	--	MOR	M	13142
plants		<i>Selenastrum capricornutum/</i> Green algae	2	72	--	3,600	--	--	--	--	IMM	M	13142
crustaceans		<i>Gammaurus fossarum/</i> Scud	5	192	--	8,494	--	--	--	--	IMM	C	11936
Ethenylbenzene		<i>Carassius auratus/</i> Goldfish	5	120	--	3,200	--	--	--	--	GRO	M	13142
fish		<i>Lepomis macrochirus/</i> Bluegill	5	96	--	4,400	--	--	--	--	GRO	M	3550
fish		<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	3	24	61,817	--	--	--	--	--	MOR	M	13419
fish		<i>Pimephales promelas/</i> Fathead minnow	17	48	64,025	--	--	--	--	--	MOR	M	13419
fish		<i>Poecilia reticulata/</i> Guppy	3	48	25,000	--	--	--	--	--	MOR	C	728
					26,000	--	--	--	--	--	MOR	C	728
					25,050	--	--	--	--	--	MOR	C	728
					25,050	--	--	--	--	--	MOR	C	728
					25,000	--	--	--	--	--	MOR	C	728
					24	--	--	--	--	--	MOR	C	728
					96	--	--	--	--	--	MOR	C	3217
					48	--	--	--	--	--	MOR	M	719
					24	--	--	--	--	--	MOR	C	728
					48	--	--	--	--	--	MOR	C	728

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)						DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC	NOEC	End-point effect		
Target analytes—Continued												
Ethylnbenzene—Continued	insects	<i>Asellus aquaticus/</i> Aquatic sowbug	5	120	59,609	--	--	--	--	--	MOR	M
	insects	<i>Daphnia magna/</i> Water flea	4	120	23,000	--	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Amphimelania holandri/</i> Snail	5	120	113,699	--	--	--	--	--	MOR	C
	invertebrates, misc.	<i>Lymania stagnalis/</i> Great pond snail	5	96	119,337	--	--	--	--	--	MOR	M
Ethylbenzene	fish	<i>Carassius auratus/</i> Goldfish	3	24	94,440	--	--	--	--	--	MOR	M
	fish	<i>Ictalurus punctatus/</i> Channel catfish	48	94,440	--	--	--	--	--	--	MOR	C
	fish	<i>Lepomis macrochirus/</i> Bluegill	6	48	32,000	--	--	--	--	--	MOR	C
	fish	<i>Menidia menidia/</i> Atlantic silverside	4	96	5,100	--	--	--	--	--	MOR	C
	fish	<i>Menidia menidia/</i> Atlantic silverside	72	72	5,800	--	--	--	--	--	MOR	C
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	96	--	--	--	--	--	3,300	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	8	96	14,000	--	--	--	--	--	MOR	C
	fish	<i>Poecilia reticulata/</i> Guppy	4	96	9,600	--	--	--	--	--	MOR	M
	insects	<i>Daphnia magna/</i> Water flea	96	97,100	--	--	--	--	--	--	MOR	C
	insects	<i>Daphnia magna/</i> Water flea	3	48	75,000	--	--	--	--	--	IMM	C
	plants	<i>Selenastrum capricornutum/</i> Green algae	12	24	77,000	--	--	--	--	--	MOR	C
	plants	<i>Selenastrum capricornutum/</i> Green algae	1	96	--	--	--	--	--	<1,000	CLR	M
	fish	<i>Brachydanio rerio/</i> Zebra danio, zebrafish	1	48	1,000	--	--	--	--	--	MOR	M
	fish	<i>Carassius auratus/</i> Goldfish	1	96	90	--	--	--	--	--	MOR	M

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC			
Target analytes—Continued											
1,1,2,3,4,4-Hexachloro-1,3-butadiene	fish	<i>Lepomis macrochirus/</i> Bluegill	3	192 96	318 324	--	--	--	--	MOR	C
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	4	192 96	121 320	--	--	--	--	MOR	C
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	96	--	140	--	--	--	LOC	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	4	96 96	90 100	--	--	--	--	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	2	768	--	--	--	--	--	GRO	C
	insects	<i>Asellus aquaticus/</i> Aquatic sowbug	2	96 72	130 160	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Lymnaea stagnalis/</i> Great pond snail	4	24 48	210 210	--	--	--	--	MOR	M
	amphibians	<i>Rana catesbeiana/</i> Bullfrog	3	96 96	2,440 2,817	--	--	--	--	MOR	M
	crustaceans	<i>Orconectes immunis/</i> Crayfish	3	96 96	>2,100 2,699	--	--	--	--	MOR	C
1,1,1,2,2,2-Hexachloroethane	fish	<i>Carassius auratus/</i> Goldfish	3	96 96	1,326 1,420	--	--	--	--	MOR	C
	fish	<i>Gambusia affinis/</i> Mosquitofish	2	96 96	1,380 1,380	--	--	--	--	MOR	M
	fish	<i>Ictalurus punctatus/</i> Channel catfish	6	96 72	1,520 1,600	--	--	--	--	MOR	C
	fish	<i>Lepomis macrochirus/</i> Bluegill	8	96 96	856 857	--	--	--	--	MOR	M
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	12	192 96	770 840	--	--	--	--	MOR	C
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	96	--	840	--	--	--	EQU	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	13	96 96	1,100 1,230	--	--	--	--	MOR	C

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)					End-point effect	DC	Source no.	
					LC ₅₀	EC ₅₀	LOEC	MATC	NOEC				
Target analytes—Continued													
1,1,1,2,2,2-Hexachloroethane—Continued	insects	<i>Ceriodaphnia reticulata/</i> Water flea	1	48	3,300	--	--	--	--	--	MOR	C	11181
	insects	<i>Ceriodaphnia reticulata/</i> Water flea	1	48	--	6,800	--	--	--	--	IMM	M	12258
	insects	<i>Daphnia magna/</i> Water flea	6	48	1,360	--	--	--	--	--	MOR	C	12004
	insects	<i>Daphnia magna/</i> Water flea	3	48	2,400	--	1,800	--	--	--	MOR	C	15981
	insects	<i>Daphnia pulex/</i> Water flea	1	48	>10,000	--	2,100	--	--	--	IMM	C	15981
	insects	<i>Daphnia pulex/</i> Water flea	1	48	--	13,000	--	--	--	--	IMM	M	11181
	insects	<i>Simocephalus vetulus/</i> Water flea	1	48	5,800	--	--	--	--	--	MOR	C	12258
	insects	<i>Tanystarsus dissimilis/</i> Midge	4	48	1,230	--	--	--	--	--	MOR	C	12004
	invertebrates, misc.	<i>Aplexa hypnorum/</i> Snail	1	96	1,231	--	--	--	--	--	MOR	M	5876
	plants	<i>Selenastrum capricornutum/</i> Green algae	5	48	>2,100	--	--	--	--	--	MOR	C	10775
	plants	<i>Selenastrum capricornutum/</i> Green algae	1	96	--	67,300	--	--	--	--	CLR	M	9607
		<i>Pimephales promelas/</i> Fathead minnow	1	96	--	87,000	--	--	--	--	CLR	M	9607
2-Methoxy-2-methylpropane	fish	<i>Brachydanio rerio/</i> Zebra danio, zebrafish	1	96	672,000	--	--	--	--	--	MOR	C	12859
Methylbenzene	crustaceans	<i>Diaptomus forbesii/</i> Calanoid copepod	1	96	447,000	--	--	--	--	--	MOR	M	11282
	fish	<i>Carassius auratus/</i> Goldfish	9	96	25,000	--	--	--	--	--	MOR	C	5938
	fish	<i>Clarias lazera/</i> Catfish	4	96	72	22,800	--	--	--	--	MOR	C	416
	fish	<i>Gambusia affinis/</i> Mosquitofish	3	96	72	25,330	--	--	--	--	MOR	C	416
	fish	<i>Ictalurus punctatus/</i> Channel catfish	1	96	1,180,000	--	--	--	--	--	MOR	C	3997
					1,260,000	--	--	--	--	--	MOR	C	3997
					240,000	--	--	--	--	--	MOR	C	508
						--	--	--	--	--	MOR	C	508
						--	--	--	--	--	MOR	C	666

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)					End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC	NOEC			
Target analytes—Continued												
Methylbenzene—Continued	fish	<i>Lepomis macrochirus/</i> Bluegill	6	96	13,000	--	--	--	--	--	MOR	C
	fish	<i>Oncorhynchus kisutch/</i> Coho salmon, silver salmon	2	96	5,500	--	--	--	--	--	MOR	C
	fish	<i>Oncorhynchus kisutch/</i> Coho salmon, silver salmon	2	1	--	8,110	--	--	--	--	MOR	M
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	2	96	1,650	--	--	--	--	--	AVO	M
	fish	<i>Oryzias latipes/</i> Medaka, high-eyes	3	96	2,340	--	--	--	--	--	AVO	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	31	96	5,800	--	--	--	--	--	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	96	24,000	--	--	--	--	--	--	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	96	54,000	--	--	--	--	--	--	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	48	63,000	--	--	--	--	--	--	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	168	168	9,390	--	--	--	--	--	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	96	12,600	--	--	--	--	--	--	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	2	168	--	82.7	--	--	--	--	BMS	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	168	--	--	110.3	--	--	--	--	GRO	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	3	768	--	--	6,000	--	--	--	GRO	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	168	--	--	8,040	--	--	--	--	GRO	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	2	168	--	--	--	--	--	5,440	GRO	M
	fish	<i>Poecilia reticulata/</i> Guppy	4	96	28,200	--	--	--	--	5,440	MOR	M
insects		<i>Aedes aegypti/</i> Mosquito	1	24	--	21,520	--	--	--	--	MOR	C
insects		<i>Chironomus riparius/</i> Midge	1	48	47,000	--	--	--	--	--	IMM	M
insects		<i>Chironomus riparius/</i> Midge	2	96-98	--	--	--	--	--	922	BEH	C
insects		<i>Daphnia magna/</i> Water flea	3	48	310,000	--	--	--	--	5,600	MOR	M
insects		<i>Daphnia magna/</i> Water flea	7	1	--	310,000	--	--	--	--	MOR	C
insects		<i>Daphnia magna/</i> Water flea		48	--	3,600	--	--	--	--	ENZ	M
insects		<i>Daphnia magna/</i> Water flea	1	504	--	6,000	--	--	--	--	IMM	M
invertebrates, misc.		<i>Brachionus calyciflorus/</i> Rotifer	2	24	113,000	--	--	--	--	1,000	REP	M
				24	113,300	--	--	--	--	--	MOR	M
						--	--	--	--	--	MOR	C
						--	--	--	--	--	9385	6002

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)					End-point effect	DC	Source no.	
					LC ₅₀	EC ₅₀	LOEC	MATC	NOEC				
Methylbenzene—Continued													
	plants	<i>Chlorella vulgaris/</i> Green algae	1	24	--	245,000	--	--	--	--	GRO	M	2215
	plants	<i>Scenedesmus subspicatus/</i> Green algae	2	48	--	125,000	--	--	--	--	GRO	M	2997
	plants	<i>Selenastrum capricornutum/</i> Green algae	2	192	--	160,000	--	--	--	--	BMS	M	2997
		<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	72	--	9,400	--	--	--	--	GRO	M	3550
		<i>Pimephales promelas/</i> Fathead minnow	1	96	2,700	--	--	--	--	--	GRO	M	13142
	fish	<i>Pimephales promelas/</i> Fathead minnow	1	96	6,320	--	--	--	--	--	MOR	M	13142
	fish	<i>Poecilia reticulata/</i> Guppy	1	96	5,100	--	--	--	--	--	MOR	M	13142
	insects	<i>Daphnia magna/</i> Water flea	1	24	95,000	--	--	--	--	--	MOR	C	5718
	insects	<i>Daphnia magna/</i> Water flea	2	48	--	601	--	--	--	--	IMM	C	11936
		<i>Selenastrum capricornutum/</i> Green algae	1	24	--	1,400	--	--	--	--	IMM	M	13142
	plants	<i>Selenastrum capricornutum/</i> Green algae	1	72	--	2,600	--	--	--	--	GRO	M	13142
	crustaceans	<i>Diaptomus forbesii/</i> Calanoid copepod	1	96	67,800	--	--	--	--	--	MOR	M	11282
	crustaceans	<i>Gammarus minus/</i> Scud	1	48	3,930	--	--	--	--	--	MOR	M	11725
	fish	<i>Gambusia affinis/</i> Mosquitofish	3	96	165,000	--	--	--	--	--	MOR	C	508
	fish	<i>Micropterus salmoides/</i> Largemouth bass	3	72	>240	--	--	--	--	--	MOR	C	508
	fish	<i>Oncorhynchus kisutch/</i> Coho salmon, silver salmon	2	168	510	--	--	--	--	--	MOR	C	10056
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	10	96	2,100	--	--	--	--	--	MOR	M	15191
	fish	<i>Pimephales promelas/</i> Fathead minnow	7	72	3,220	--	--	--	--	--	MOR	M	477
	insects	<i>Chironomus attenuatus/</i> Midge	5	48	110	--	--	--	--	--	MOR	C	10056
	insects	<i>Daphnia magna/</i> Water flea	8	48	120	--	--	--	--	--	MOR	C	10056
					1,990	--	--	--	--	--	MOR	M	11725
					6,080	--	--	--	--	--	MOR	C	10954
					13,000	--	--	--	--	--	MOR	M	11725
					3,400	--	--	--	--	--	MOR	C	7049
					2,160	--	--	--	--	--	MOR	M	11725
					3,400	--	--	--	--	--	MOR	C	10359

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)						End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC	NOEC				
Target analytes—Continued													
Naphthalene—Continued	insects	<i>Daphnia magna</i> /Water flea	6	2	--	690	--	--	--	--	PTR	M	46
	insects	<i>Daphnia pulex</i> /Water flea	2	96	1,000	--	2,194	--	--	--	IMM	M	6026
	insects	<i>Daphnia pulex</i> /Water flea	2	48	2,920-3,890	--	--	--	--	--	MOR	M	15337
	insects	<i>Somatochlora cingulata</i> /Dragonfly	1	96	1,000-2,500	--	--	--	--	--	IMM	C	15293
	insects	<i>Tanytarsus dissimilis</i> /Midge	4	48	12,200	--	--	--	--	--	MOR	C	3283
	invertebrates, misc.	<i>Physa gyrina</i> /Pouch snail	1	48	12,600	--	--	--	--	--	MOR	C	15486
	invertebrates, misc.	<i>Nitzschia palea</i> /Diatom	1	48	5,020	--	--	--	--	--	MOR	M	4399
	plants	<i>Chlorella vulgaris</i> /Green algae	1	24	--	33,000	--	--	--	--	GRO	M	7049
	plants	<i>Selenastrum capricornutum</i> /Green algae	1	4	--	2,820	--	--	--	--	PSE	M	11725
	plants	<i>Carassius auratus</i> /Goldfish	1	24	380,000	--	--	--	--	--	PSE	M	2215
	fish	<i>Lepomis macrochirus</i> /Bluegill	1	96	7,000,000	--	--	--	--	--	PSE	M	11725
	fish	<i>Pimephales promelas</i> /Fathead minnow	2	96	91,700	--	--	--	--	--	MOR	C	623
2,2-Oxybis[propane]	amphibians	<i>Xenopus laevis</i> /Clawed toad	1	96	786,000	--	--	--	--	--	MOR	C	863
2-Propenal	fish	<i>Amia calva</i> /Bowfin	1	24	7	--	--	--	--	--	MOR	C	10183
	fish	<i>Carassius auratus</i> /Goldfish	1	24	62	--	--	--	--	--	MOR	C	12447
	fish	<i>Catostomus commersonii</i> /White sucker	1	96	<80	--	--	--	--	--	MOR	C	12665
	fish	<i>Gambusia affinis</i> /Mosquitofish	2	48	61	--	--	--	--	--	MOR	C	2092
	fish	<i>Lepomis macrochirus</i> /Bluegill	8	96	149	--	--	--	--	--	MOR	C	12665
				24	33	--	--	--	--	--	MOR	C	938

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC			
Target analytes—Continued											
2-Propenal—Continued	fish	<i>Micropterus salmoides/</i> Largemouth bass	4	72	160	—	—	—	—	MOR	C
	fish	<i>Oncorhynchus kisutch/</i> Coho salmon, silver salmon	1	96	68	—	—	—	—	MOR	C
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	3	96	16	—	—	—	—	MOR	C
	fish	<i>Oncorhynchus tshawytscha/</i> Chinook salmon	1	24	29	—	—	—	—	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	6	96	14	—	—	—	—	MOR	C
	fish	<i>Rasbora heteromorpha/</i> Harlequinfish, red rasbora	2	48	60	—	—	—	—	MOR	C
	fish	<i>Salmo trutta/</i> Brown trout	2	24	46	—	—	—	—	MOR	C
	insects	<i>Daphnia magna/</i> Water flea	3	48	57	—	—	—	—	MOR	M
	insects	<i>Daphnia magna/</i> Water flea	2	48	83	—	—	—	—	MOR	C
	insects	<i>Tanytarsus dissimilis/</i> Midge	1	48	—	51	—	—	—	IMM	C
	invertebrates, <i>Aplexa hypnorum/</i> misc.		1	96	>151	—	—	—	—	MOR	C
2-Propenonitrile											
	fish	<i>Brachydanio rerio/</i> Zebra danio, zebrafish	1	48	15,000	—	—	—	—	MOR	M
	fish	<i>Carassius auratus/</i> Goldfish	1	24	24,000	—	—	—	—	MOR	M
	fish	<i>Lepomis macrochirus/</i> Bluegill	19	96	9,300	—	—	—	—	MOR	C
	fish	<i>Oryzias latipes/</i> Medaka, high-eyes	2	48	32,000	—	—	—	—	MOR	C
	fish	Osteichthyes/ Bony fish class	1	72	50,000	—	—	—	—	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	16	720	40,000	—	—	—	—	MOR	M
	fish	<i>Poecilia reticulata/</i> Guppy	3	48	33,500	—	—	—	—	MOR	M
				96	33,500	—	—	—	—	MOR	M

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	NOEC			
Target analytes—Continued											
2-Propenenitrile—Continued	insects	<i>Daphnia magna/</i> Water flea	2	48	7,600	—	—	—	—	MOR	C
	insects	<i>Daphnia magna/</i> Water flea	1	48	13,000	—	—	—	—	MOR	C
<i>n</i> -Propylbenzene	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	96	1,550	—	—	—	—	MOR	M
	insects	<i>Daphnia magna/</i> Water flea	1	24	—	2,000	—	—	—	IMM	M
Tetrachloroethene	plants	<i>Selenastrum capricornutum/</i> Green algae	1	72	—	1,800	—	—	—	GRO	M
	fish	<i>Jordanella floridae/</i> Flagfish	6	96	4,000	—	—	—	—	MOR	M
	fish	<i>Jordanella floridae/</i> Flagfish	3	240	—	—	3,100	—	—	MOR	M
	fish	<i>Lepomis macrochirus/</i> Bluegill	2	96	13,000	—	—	—	—	MOR	C
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	11	768	1,400	—	—	—	—	MOR	C
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	768	—	—	—	—	—	IMM	C
	fish	<i>Oryzias latipes/</i> Medaka, high-eyes	1	48	1,600	—	—	—	—	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	11	96	13,400	—	—	—	—	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	4	24	—	14,400	—	—	—	IMM	C
	insects	<i>Daphnia magna/</i> Water flea	4	48	—	14,400	—	—	—	IMM	C
	insects	<i>Daphnia magna/</i> Water flea	3	24	—	9,100	—	—	—	MOR	C
	insects	<i>Moina macrocopa/</i> Water flea	1	3	—	18,000	—	—	—	IMM	C
	insects	<i>Tanypus dissimilis/</i> Midge	2	48	30,800	—	—	—	—	MOR	M
	insects	<i>Tanypus dissimilis/</i> Midge	24	54,600	—	—	—	—	—	MOR	C

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)			End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC			
Target analytes—Continued										
Tetrachloroethene—Continued	invertebrates, misc.	<i>Dugesia japonica/</i> Flatworm	1	168	1,400	--	--	--	MOR	M
	invertebrates, misc.	<i>Dugesia japonica/</i> Flatworm	1	168	--	900	--	--	RGN	M
plants	plants	<i>Selenastrum capricornutum/</i> Green algae	4	24	--	>500,000	--	--	CLR	M
	plants	<i>Selenastrum capricornutum/</i> Green algae	48	48	--	>500,000	--	--	CLR	M
Tetrachloromethane	amphibians	<i>Bufo woodhousei fowleri/</i> Fowler's toad	2	168	--	2,830	--	--	<500,000	CLR
	amphibians	<i>Rana catesbeiana/</i> Bullfrog	1	96	--	>92,000	--	--	TER	C
amphibians	amphibians	<i>Rana palustris/</i> Pickerel frog	2	192	--	2,370	--	--	TER	C
	amphibians	<i>Rana pipiens/</i> Leopard frog	1	192	--	3,620	--	--	TER	C
fish	fish	<i>Lepomis macrochirus/</i> Bluegill	3	96	27,000	--	--	--	MOR	C
	fish	<i>Oryzias latipes/</i> Medaka, high-eyes	7	48	38,000	--	--	--	MOR	C
fish	fish	<i>Pimephales promelas/</i> Fathead minnow	2	96	2,000	--	--	--	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	24	96	670,000	--	--	--	MOR	M
fish	fish	<i>Pimephales promelas/</i> Fathead minnow	1	168	41,400	--	--	--	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	43,100	--	--	--	--	--	MOR	C
fish	fish	<i>Pimephales promelas/</i> Fathead minnow	1	168	73,200	--	--	--	MOR	C
	fish	<i>Pimephales promelas/</i> Fathead minnow	1	168	--	--	--	52,100	--	MOR
fish	fish	<i>Pimephales promelas/</i> Fathead minnow	1	168	--	--	--	--	37,100	MOR
	insects	<i>Daphnia magna/</i> Water flea	3	24	35,000	--	--	--	MOR	C
insects	insects	<i>Daphnia magna/</i> Water flea	48	48	35,000	--	--	--	MOR	C
	insects	<i>Moina macrocopa/</i> Water flea	1	3	2,300	--	--	--	IMM	M
invertebrates, misc.	invertebrates,	<i>Dugesia japonica/</i> Flatworm	1	168	200	--	--	--	MOR	M
	invertebrates, misc.	<i>Dugesia japonica/</i> Flatworm	1	168	--	--	--	--	MOR	12513

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)			End-point effect	DC	Source no.	
					LC ₅₀	EC ₅₀	LOEC				
Target analytes—Continued											
Tetrachloromethane—Continued	invertebrates, misc.	<i>Dugesia japonica/</i> Flatworm	1	168	--	1,500	--	--	RGN	M	12513
Tribromomethane	fish	<i>Cyprinus carpio/</i> Common, mirror, colored carp	2	72-120	52,000	--	--	--	MOR	M	6360
	fish	<i>Lepomis macrochirus/</i> Bluegill	2	96	29,000	--	--	--	MOR	M	6360
	insects	<i>Daphnia magna/</i> Water flea	2	24	33,000	--	--	--	MOR	C	5590
	insects	<i>Daphnia pulex/</i> Water flea	1	96	44,000	--	--	--	MOR	C	5590
	plants	<i>Selenastrum capricornutum/</i> Green algae	5	96	--	38,600	--	--	CLR	M	9607
	plants	<i>Selenastrum capricornutum/</i> Green algae	1	96	--	40,100	--	--	PGR	M	9607
1,2,3-Trichlorobenzene	fish	<i>Brachydanio rerio/</i> Zebra danio, zebrafish	2	672	990	--	--	--	MOR	M	9607
	fish	<i>Brachydanio rerio/</i> Zebra danio, zebrafish	4	168	3,100	--	--	--	MOR	M	15526
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	336	--	--	--	--	450 REP	M	3279
	fish	<i>Poecilia reticulata/</i> Guppy	1	48	710	--	--	--	450 REP	M	3279
	insects	<i>Chironomus riparius/</i> Midge	3	96	348	--	--	--	MOR	M	15526
	insects	<i>Chironomus riparius/</i> Midge	24	48	686	--	--	--	MOR	M	4072
	insects	<i>Chironomus riparius/</i> Midge	1	48	1,700	--	--	--	MOR	C	4072
	insects	<i>Daphnia magna/</i> Water flea	7	96-98	--	--	--	18 BEH	C	14176	
	insects	<i>Daphnia magna/</i> Water flea	24	48	--	--	--	340 MOR	M	4072	
	plants	<i>Cyclotella meneghiniana/</i> Diatom	1	96	--	--	--	REP	M	15526	
1,2,4-Trichlorobenzene	crustaceans	<i>Orconectes immunis/</i> Crayfish	1	48	--	200	--	--	IMM	M	15526
				3,020	--	350	--	--	REP	M	847
					--	6,420	--	--	CYT	C	88
						--	--	--	MOR	C	12665

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.	
					LC ₅₀	EC ₅₀	LOEC	NOEC				
Target analytes—Continued												
1,2,4-Trichlorobenzene—Continued	fish	<i>Brachydanio rerio/</i> Zebra danio, zebrafish	1	48	6,300	—	—	—	—	MOR	M	15526
	fish	<i>Jordanella floridae/</i> Flagfish	6	96	1,217	—	—	—	—	MOR	M	140
	fish	<i>Jordanella floridae/</i> Flagfish	1	240	—	—	1,130	—	—	MOR	M	140
	fish	<i>Lepomis macrochirus/</i> Bluegill	3	96	3,020	—	—	—	—	MOR	C	12665
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	10	192	1,280	—	—	—	—	MOR	C	5590
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	2,304	—	1,270	—	—	—	MOR	C	10579
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	7	2,040	—	—	470	—	—	GRO	M	12665
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	9	1,080	—	—	—	—	406	—	GRO	C
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	2,040	—	—	—	—	—	406	—	GRO	C
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	7	1,080	—	—	—	—	—	350	GRO	M
	fish	<i>Oryzias latipes/</i> Medaka, high-eyes	1	48	1,100	—	—	—	—	350	GRO	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	3	96	2,760	—	—	—	—	MOR	M	6914
insects	insects	<i>Daphnia magna/</i> Water flea	5	48	1,700	—	—	—	—	MOR	C	6914
		<i>Daphnia magna/</i> Water flea	4	336	—	2,100	—	—	—	MOR	C	15981
	insects	<i>Moina macrocopa/</i> Water flea	1	3	1,400	—	—	—	—	REP	M	15526
		<i>Tanytarsus dissimilis/</i> Midge	1	48	930	—	—	—	—	IMM	M	15526
invertebrates, misc.	invertebrates, misc.	<i>Aplexa hypnorum/</i> Snail	1	96	3,160	—	—	—	—	MOR	C	12665
		<i>Dugesia japonica/</i> Flatworm	1	168	1,100	—	—	—	—	MOR	M	12513
	invertebrates, misc.	<i>Dugesia japonica/</i> Flatworm	1	168	—	1,100	—	—	—	RGN	M	12513

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)					DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC	NOEC		
Target analytes—Continued											
1,1,2-Trichloroethane—Continued	insects	<i>Chironomus riparius/</i> Midge	1	48	147,000	--	--	--	--	MOR	C
	insects	<i>Chironomus riparius/</i> Midge	1	48	--	--	--	--	<31,000	MOR	M
	insects	<i>Daphnia magna/</i> Water flea	17	48	18,000	--	--	--	--	MOR	C
	insects	<i>Daphnia magna/</i> Water flea	3	72	--	32,000	--	--	--	REP	M
	invertebrates, misc.	<i>Dreissena polymorpha/</i> Zebra mussel	3	336	140,000	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Lyymnaea stagnalis/</i> Great pond snail	2	384	58,000	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Lyymnaea stagnalis/</i> Great pond snail	2	96	170,000	--	--	--	--	MOR	M
1,1,2-Trichloroethene	amphibians	<i>Xenopus laevis/</i> Clawed toad	1	48	45,000	--	--	--	--	MOR	M
	amphibians	<i>Ambystoma mexicanum/</i> Mexican axolotl	1	48	48,000	--	--	--	--	MOR	M
	crustaceans	<i>Gammarus pulex/</i> Scud	1	48	24,000	--	--	--	--	MOR	M
	fish	<i>Brachydanio rerio/</i> Zebra danio, zebrafish	1	48	60,000	--	--	--	--	MOR	M
	fish	<i>Jordanella floridae/</i> Flagfish	7	96	3,100	--	--	--	--	MOR	M
	fish	<i>Jordanella floridae/</i> Flagfish	3	240	28,280	--	--	--	--	MOR	M
	fish	<i>Lepomis macrochirus/</i> Bluegill	2	96	45,000	--	--	--	--	MOR	C
	fish	<i>Oncorhynchus mykiss/</i> Rainbow trout, donaldson trout	1	48	>68,000-<100,000	--	--	--	--	MOR	M
	fish	<i>Oryzias latipes/</i> Medaka, high-eyes	8	48	1,900	--	--	--	--	MOR	M
	fish	<i>Pimephales promelas/</i> Fathead minnow	11	72	39,000	--	--	--	--	MOR	C

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC	NOEC		
Target analytes—Continued											
1,1,2-Trichloroethene—Continued	invertebrates, misc.	<i>Eryobdella octoculata/ Leech</i>	1	48	75,000	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Hydra oligactis/ Hydra</i>	2	48	75,000	--	--	--	--	MOR	M
	invertebrates, misc.	<i>Lymnaea stagnalis/ Great pond snail</i>	2	48	56,000	--	--	--	--	MOR	M
	invertebrates, misc.	Oligochaeta (order)/ Tubificidae (family)	1	48	132,000	--	--	--	--	MOR	M
	plants	<i>Scenedesmus abundans/ Green algae</i>	1	96	--	450,000	--	--	--	GRO	M
Trichloromethane	amphibians	<i>Bufo woodhousei fowleri/ Fowler's toad</i>	2	168	--	35,140	--	--	--	TER	C
	amphibians	<i>Hyla crucifer/ Spring peeper</i>	2	168	--	>40,000	--	--	--	TER	C
	amphibians	<i>Rana palustris/ Pickerel frog</i>	2	192	72	--	270	--	--	TER	C
	amphibians	<i>Rana pipiens/ Leopard frog</i>	2	96	--	20,550	--	--	--	TER	C
	crustaceans	<i>Penaeus dhorarum/ Pink shrimp (American)</i>	1	96	--	--	--	28,170	--	TER	C
	fish	<i>Brachydanio rerio/ Zebra danio, zebrafish</i>	1	48	100,000	--	--	--	--	MOR	M
	fish	<i>Cyprinus carpio/ Common, mirror, colored, carp</i>	1	72-120	97,000	--	--	--	--	MOR	M
	fish	<i>Ictalurus punctatus/ Channel catfish</i>	6	96	75,000	--	--	--	--	MOR	C
	fish	<i>Lepomis macrochirus/ Bluegill</i>	33	168	101,000	--	--	--	--	MOR	C
	fish	<i>Lepomis macrochirus/ Bluegill</i>	96	2,030	--	--	--	--	--	MOR	C
	fish	<i>Micropterus salmoides/ Largemouth bass</i>	17	96	13,300	--	--	--	--	75,000	M
	fish	<i>Oncorhynchus mykiss/ Rainbow trout, donaldson trout</i>	29	672	1,240	--	--	--	--	100,000	MOR
	fish	<i>Oncorhynchus mykiss/ Rainbow trout, donaldson trout</i>	2	672	1,240	--	--	--	--	24,000	MOR
			96	--	--	--	--	--	--	42,000	MOR

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC			
Other analytes—Continued											
2-Propanone—Continued	insects	<i>Daphnia magna</i> / Water flea	4	216-264	--	--	--	--	<403,000	MOR	M
				216-264	--	--	--	--	3,110,000	REP	M
	insects	<i>Daphnia pulex</i> / Water flea	3	18	1,220,000	--	--	--	--	MOR	M
	insects	<i>Ischnura elegans</i> / Dragonfly	1	48	8,800,000	--	--	--	--	MOR	M
	insects	<i>Moina macrocopa</i> / Water flea	1	3	6,400,000	--	--	--	--	MOR	M
	insects	<i>Nemoura cinerea</i> / Stonefly	1	48	15,000,000	--	--	--	--	MOR	M
	invertebrates,	<i>Anodonta imbecillis</i> / Mussel	1	48	10,300,000	--	--	--	--	MOR	M
	invertebrates,	<i>Brachionus calyciflorus</i> / Rotifer	1	24	51,000	--	--	--	--	MOR	M
	invertebrates,	<i>Cipangopaludina malleata</i> / Mud snail	1	48	48,000,000	--	--	--	--	MOR	M
	invertebrates,	<i>Corbicula manilensis</i> / Asiatic clam	1	96	>20,000,000	--	--	--	--	MOR	M
	invertebrates,	<i>Dugesia lugubris</i> / Turbellarian, flatworm	2	96	>100,000	--	--	--	--	MOR	C
	invertebrates,	<i>Erpobdella octoculata</i> / Leech	1	48	7,500,000	--	--	--	--	MOR	M
	invertebrates,	<i>Erpobdella octoculata</i> / Leech	1	48	7,000,000	--	--	--	--	MOR	M
	invertebrates,	<i>Helisoma trivolvis</i> / Ramshorn snail	1	96	100,000	--	--	--	--	MOR	M
	invertebrates,	<i>Hydra oligactis</i> / Hydra	2	48	13,500,000	--	--	--	--	MOR	M
	invertebrates,	<i>Indoplanorbis exustus</i> / Snail	1	48	13,500,000	--	--	--	--	MOR	M
	invertebrates,	<i>Limnaea stagnalis</i> / Great pond snail	2	48	35,000,000	--	--	--	--	MOR	M
	invertebrates,	<i>Paramecium caudatum</i> / Ciliate	1	4	5,227,200	--	--	--	--	MOR	M

Table 5. Aquatic toxicity information for selected volatile organic compounds measured by the U.S. Geological Survey—Continued

IUPAC compound name	Taxonomic classification	Genus, species/ common name	n	Duration (hours)	Measures of toxicity (micrograms per liter)				End-point effect	DC	Source no.
					LC ₅₀	EC ₅₀	LOEC	MATC			
Other analytes—Continued											
1,1,2,2-Tetrachloro-ethane—Continued	plants	<i>Selenastrum capricornutum/</i> Green algae	5	48	--	73,400	--	--	--	CLR	M
	plants	<i>Selenastrum capricornutum/</i> Green algae	1	96	--	76,900	--	--	--	CLR	M
1,3,5-Trimethylbenzene	fish	<i>Carassius auratus/</i> Goldfish	4	96	12,520	--	--	--	--	MOR	C
	insects	<i>Daphnia magna/</i> Water flea	2	48	--	13,650	--	--	--	MOR	C
	insects	<i>Daphnia magna/</i> Water flea	1	24	--	6,011	--	--	--	IMM	C
	plants	<i>Scenedesmus subspicatus/</i> Green algae	2	504	--	50,000	--	--	--	IMM	C
			48	--	--	400	--	--	--	REP	M
				--	--	--	--	--	--	BMS	M
				--	--	--	--	--	--	GRO	M
				--	--	--	--	--	--	2997	2997

**REFERENCES CONTAINING
AQUATIC TOXICITY INFORMATION**

Table 6. References containing aquatic toxicity information for selected volatile organic compounds as described in this study

[Source number may be used to retrieve citation from AQUIRE data base (U.S. Environmental Protection, 1996a)]

Source no. (table 5)	References cited
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Table 6. References containing aquatic toxicity information for selected volatile organic compounds as described in this study—Continued

Source no. (table 5)	References cited
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Table 6. References containing aquatic toxicity information for selected volatile organic compounds as described in this study—Continued

Source no. (table 5)	References cited
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Table 6. References containing aquatic toxicity information for selected volatile organic compounds as described in this study—Continued

Source no. (table 5)	References cited
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Table 6. References containing aquatic toxicity information for selected volatile organic compounds as described in this study—Continued

Source no. (table 5)	References cited
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Table 6. References containing aquatic toxicity information for selected volatile organic compounds as described in this study—Continued

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